# POWER PLANT ENGINEERING

Established Over 32 Years

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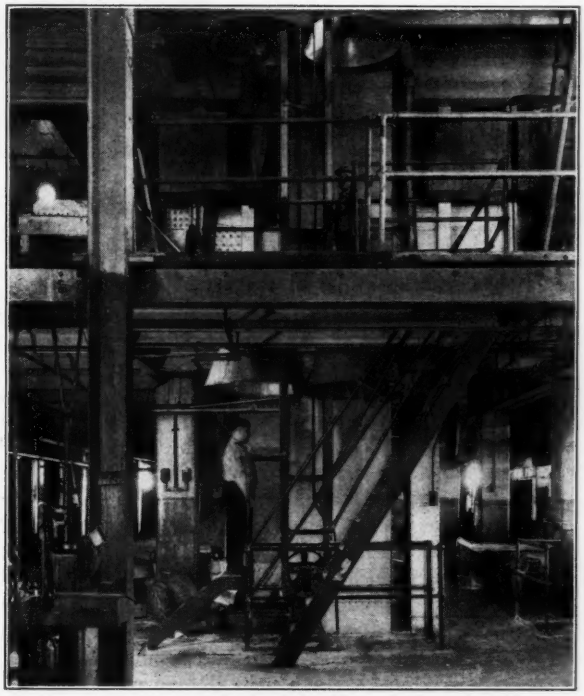


## The Uplift Movement in Philadelphia

IT IS EMINENTLY FITTING that in the City of Brotherly Love there should be an organization devoted to spreading sweetness and light throughout the nation. Well, sweetness, anyway, for it is the Pennsylvania Sugar Co. to which we refer. Possibly the mighty Arnold (no, not Benedict; the other one) drew inspiration from this company in writing his famous essay on sweetness and light. At any rate, the above illustration shows certain phases of the uplift movement, as carried on there.

We do not wish to imply that the City of Brotherly Love needs to be uplifted any more than other cities. But we wonder whether or not the above picture was ever called to the attention of the famous brigadier-general of marines who encountered such difficulty in his endeavors to purify the great city by the Delaware, thereby adding to the fame it already enjoyed as a result of Benj. Franklin, the Chesapeake oyster, scrapple and the Atlantic City bathing beauty contests. Possibly the general would have been considerably puzzled to reconcile the company's uplift activities with its production of al—h–l as a by-product (you know—the stuff you put in your automobile radiator in winter).

At any rate, on page 985 of this issue, Dan Gutleben, plant engineer for the company, tells you all about it.

# Centralized Power Plant for Paper Mills

By
Warren D. Spengler*

HIGH-PRESSURE PLANT MEETS PAUL A. SORG PAPER CO.'S NEEDS. IT SUPPLIES POWER AND PROCESS STEAM FROM BLEEDER TURBINES AND BURNS COAL OR OIL

JUST COMPLETED AND PUT into operation by the Paul A. Sorg Paper Co. is a power plant that is characterized by low first cost and high operating efficiency, which means low operating costs. This plant is more than meeting the expectations of the management and it is thought that others confronted with the problem of reduction of steam and power costs will be interested in the story of this development from the original study through to the final completion and actual operation of the new power plant.

All located in Middletown, Ohio, on adjacent property, the Paul A. Sorg Paper Co., the W. B. Oglesby Paper Co. and the Frank Smith Paper Co. are operated under the supervision of the same group of officials, with J. A. Aull as president of all three mills.

Like all progressive industries, these mills have grown steadily. Consequently, they have made increased demands for steam and power which were met from time to time in various ways, such as replacement of engine drive with larger motor drive, necessitating installation of turbine generator equipment and additional boiler equipment. When further growth demanded more power and no more space was available for power generating equipment, resort was had to the supply from a public utility.

All this gradually led to a situation where steam was supplied from two separate boiler houses and power was supplied by means of miscellaneous engine drives, turbine generator units, and public utility supply lines. Such a situation was not conducive to continuity of steam and power supply and in addition resulted in high cost.

*President of Warren D. Spengler, Inc., Engineers, Cleveland, Ohio.

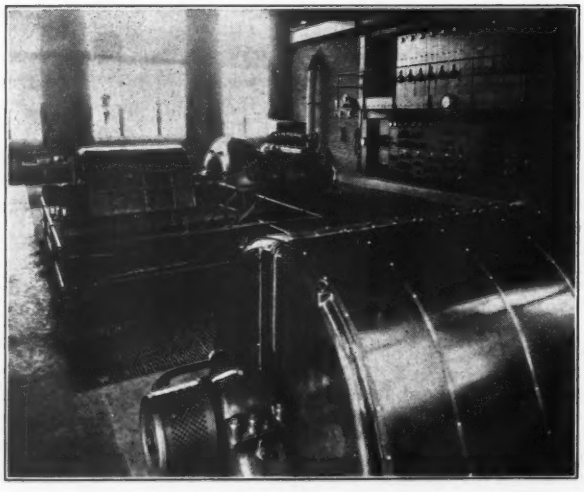


FIG. 1. POWER IS SUPPLIED BY TWO 5000-KW. BLEEDER TURBINE UNITS

## NEED AROSE FOR A NEW PLANT

Some of the equipment was nearing its full age of usefulness. All of it was carrying maximum possible loads. The operating cost for labor of attendance was high because of the great number of small units and the repair costs were high because of the age of the equipment. No reduction in these items was possible without some radical change; furthermore, there was no reserve equipment and the cost of providing a reserve was prohibitive.

With frequent interruptions in the supply and with the trend toward greater demands, it became apparent that another source of supply was absolutely necessary. It was therefore decided to study the situation with a view to developing the best procedure for securing increased steam and power generating capacity, assured continuity of supply and lower operating costs.

When a study was instituted, it brought out the following salient points:

1. The actual consumption by the various mills of steam and power,—hourly, daily, monthly—averages and maxima. The actual production of paper in the same detail with its relation to steam and power.

2. Layout of a tentative power plant that would meet the requirements of all three mills, outlined as to size of units, operating characteristics and efficiencies and defined in preliminary sketches.

3. An estimate, with necessary detail, of investment required by such a plant.

4. An estimate of operating cost for such a plant for a given annual paper production, with the gross net advantages over the present costs.

5. With these data at hand, a careful comparison was made and because of the favorable net saving of a central plant, it was recommended to abandon the two old boiler plants, the engine driving line shafting and generators, the small turbine generators and the purchase of power from the public utility.

6. In place of these latter sources of steam and power, it was recommended to develop a modern high-pressure, high-temperature, steam-electric generating plant, having few units operating at high ratings, with low labor of attendance and low maintenance costs, and to complete the electrification of all mills.

Careful consideration was also given to several suggestions from the public utility company that involved partial supply of power from the utility's high-tension supply lines and the balance from a process steam plant, both low-pressure and high-pressure; but none of the schemes suggested, when analyzed, could show any economic advantage.

With the necessity of supplying low pressure steam for process to all three mills from a single power plant, the location of the latter was as near the geographical center as possible.

### Water Power for Stand-By

Other considerations, such as the supply of circulating water for the condensers from the canal, the delivery of coal from cars to the plant and the location of coal storage facilities adjacent to the plant, as well as its relation to the center of electrical load, soil conditions that affect foundations, flood water limitations, —all had a bearing on the selection of the exact site for the power house building. Figure 1 shows this building in relation to the mills, the canal and the coal track.

Inasmuch as the proposed development included a severing of connections with the public utility lines, it was necessary to have a source of power supply as stand-by.

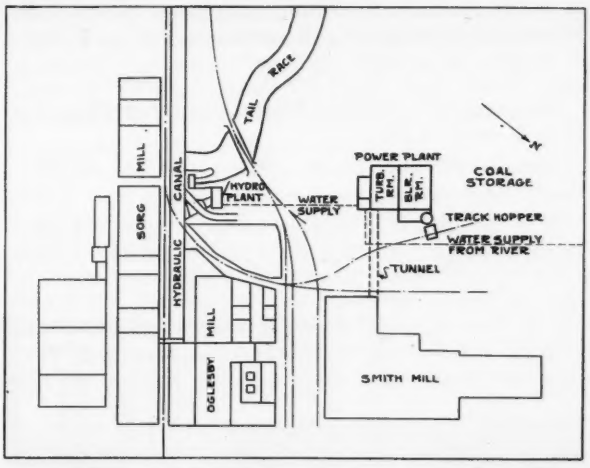



FIG. 2. POWER PLANT WAS LOCATED WITH REGARD TO WATER, COAL AND PROCESS STEAM SUPPLY

The company has a contract for water supply with the hydraulic company, owners of the canal and river water rights and had been operating three small water wheels for use in driving beaters. These wheels were old and ready for replacement. It was therefore logical to abandon them and install a single water wheel driving an electric generator. A new location, shown in Fig. 1, was selected and necessary hydraulic development constructed to accomplish this.

This water wheel generator equipment is fully automatic and requires no station attendant. It has a capacity of 350 kw., normally expected to deliver 250 kw. into the station bus at the power house. Incidentally, the intake for this water wheel serves also for the circulating water supply.

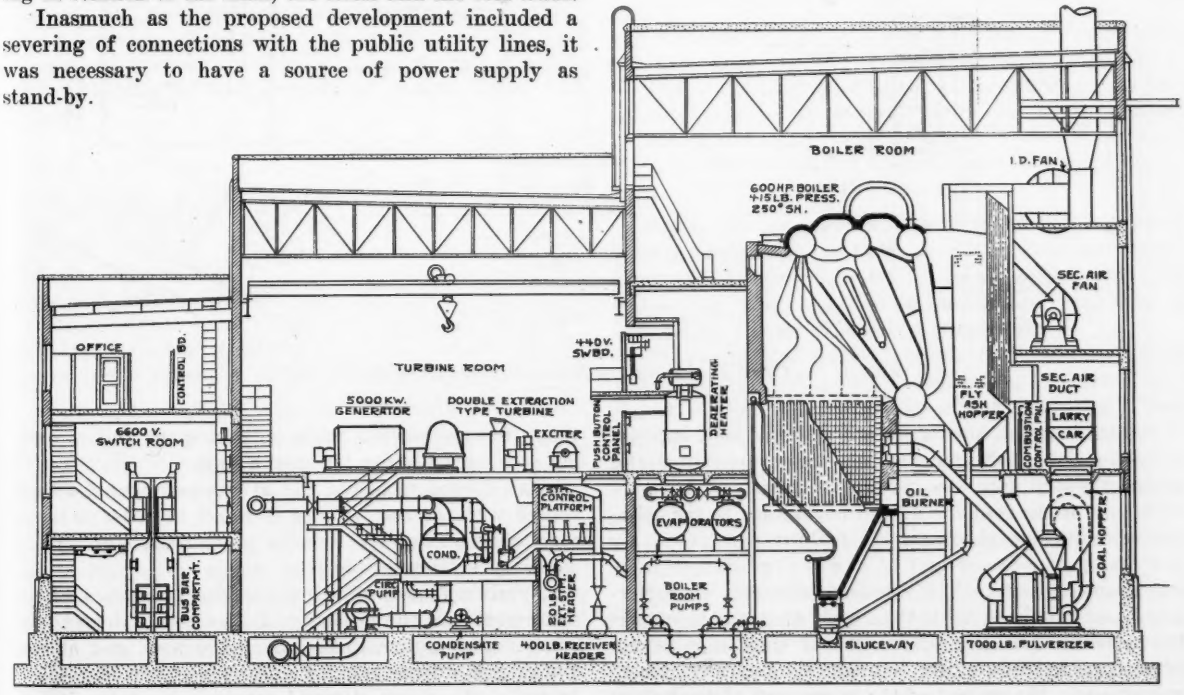



FIG. 3. BOTH PULVERIZED COAL AND OIL FUEL ARE PROVIDED. EXTRACTION AT 50 AND 20 LB. IS PRACTICED FOR PROCESS STEAM

In the matter of selecting equipment, the facts developed in the study of mill operations were as follows:

| Requirements | Present Average | Present Maximum | Future Average | Future Maximum |
|---|---|---|---|---|
| Process steam at 20 lb. gage, lb. per hr... | 34,200 | 44,300 | 44,200 | 57,340 |
| Process steam at 50 lb. gage, lb. per hr... | 2,800 | 3,570 | 3,800 | 4,700 |
| Power demand, kw.. | 3,230 | 4,110 | 3,970 | 5,144 |

To these requirements were added the load imposed by steam for feedwater heating and evaporation and other auxiliary uses, also power for auxiliary drive.

Study of the combined requirements led to the selection of a turbine generator of 5000-kw. capacity at 80 per cent power factor and of two boilers of 2500-b.hp. maximum capacity. The question of steam characteristics was analyzed with the result that steam at 400 lb. pressure, 250 deg. F. superheat showed a saving over steam of 250 lb. and 100 deg. F. superheat, which amounted to 26 per cent of the excess cost of equipment incurred under the higher boiler pressure. This was deemed attractive and the high pressure was decided upon.

Inasmuch as a single source of supply for steam and power was recommended for all three mills, assurance of continuity of supply was an absolute necessity. This led to the installation of reserve units for all equipment whose failure to operate would interfere with the continuity of supply. Each boiler unit, however, had a capacity to care for demands of all three mills with 10 per cent excess capacity over the average and provision for reserve was made only in space and supporting structure allotted for such a unit.

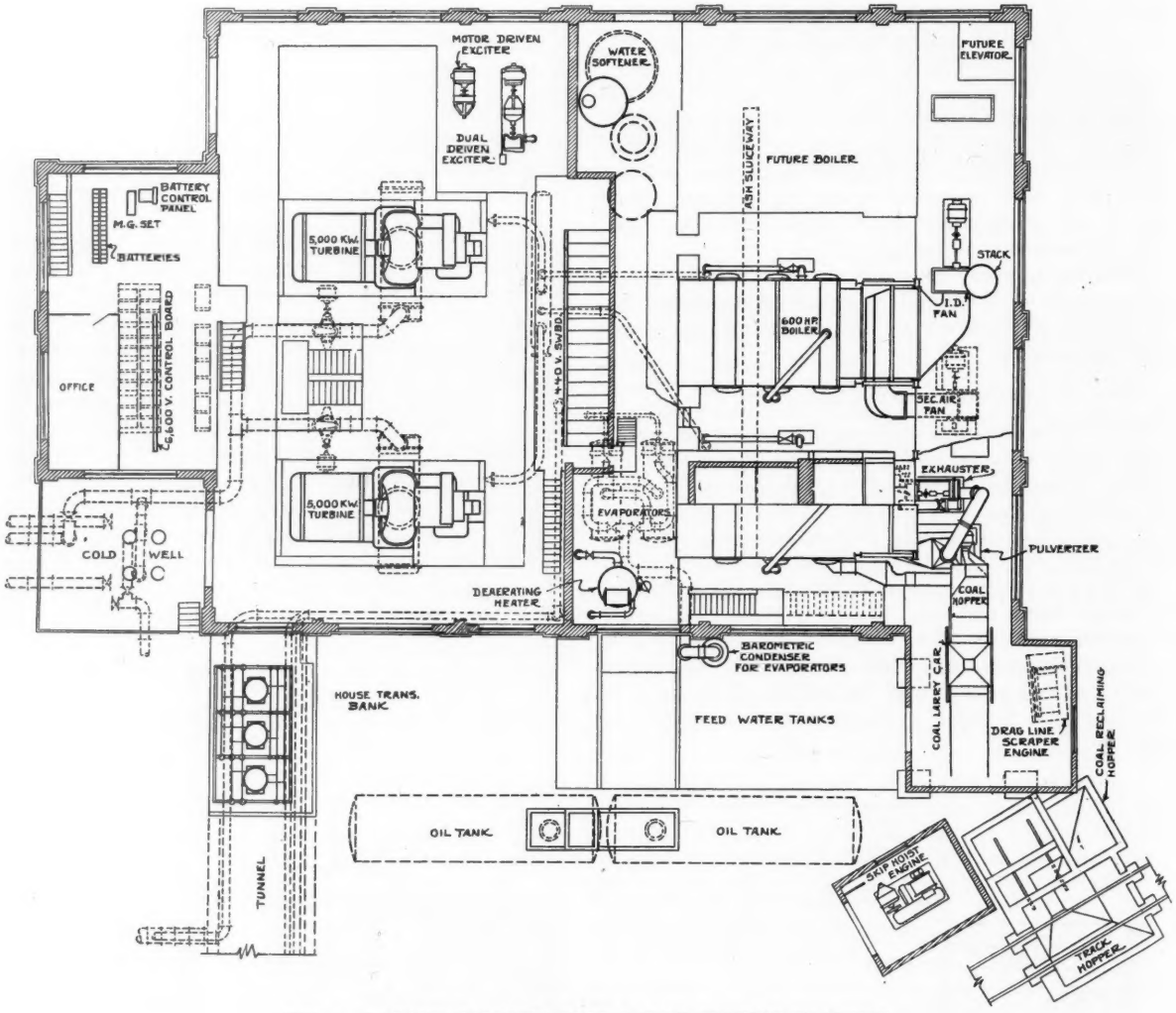



FIG. 4. LAYOUT FOLLOWS BEST LARGE STATION PRACTICE

Another factor affecting the characteristics of the equipment was the necessity of its meeting demands by operating at high ratings during the week and at very low ratings during Sunday and holiday periods. As an example, the steam demand would vary from 100 up to 2500 b.hp. and the load demand from 50 up to 4800

As referred to above, the hydroelectric unit was installed with the reserve idea in mind, in order to secure continuity of supply from the station transformers for auxiliary station power.

kw. For these low steam demands, provision was made to operate the boilers on oil instead of on coal and, for the low power demands, the hydroelectric plant would be relied upon. The new power plant was then developed with the principal equipment, listed in the attached table, having the characteristics outlined above.

### Building and Plant Arrangement

General arrangement of the plant and equipment is shown in Figs. 2 and 3. The building rests upon a good gravel bed and a reënforced concrete mat, 3 ft. thick, with longitudinal reënforced ribs supporting the building proper. This mat and the walls from the mat up for 11 ft. are built to withstand the action of high water; consequently, there is no opening in the basement below high-water level, except for the water supply line to the fire system.

As to other details of the building design, there is nothing that differentiates it from the usual concrete, steel and brick construction; but a comparatively large amount of subway grating, instead of concrete floors, has been used throughout and all stairways have treads of the same construction. In the sash, actinic glass has been used, with the idea of eliminating the glare that results from large areas of sash with ordinary glass. It is proving satisfactory.

In the west wall of the boiler room, the sash has been set into channel-iron frames which are hung on hinges to permit the window openings to be used as entrances for moving equipment into or out of the building.

### Water Supply Is Treated

With the plan to operate the boilers at high ratings and with maximum efficiency, it was decided to use utmost care in the treatment of water supply for boiler use and to provide constant check against contamination of condensate returns. Raw water for boiler feed supply comes from a well adjacent to the power plant. The following is the analysis of sample from well supply:

| | |
|---|---|
| Organic and Volatile | 1.769 |
| Silica ($SiO_2$) | 0.151 |
| Iron Oxide ($Fe_2O_3$) | Trace |
| Alumina ($Al_2O_3$) | Trace |
| Sodium Chloride (NaCl) | 0.487 |
| Sodium Sulphate ($Na_2SO_4$) | 0.389 |
| Calcium Sulphate ($CaSO_4$) | 2.158 |
| Calcium Carbonate ($CaCO_3$) | 10.330 |
| Magnesium Carbonate (Mfg. $C.O_3$) | 4.820 |
| Total solids by evaporation = | 20.104 |
| Free Sulphuric acid | Nil |
| Suspended matter | Nil |

For the purpose of raw water purification, lime-barium-carbonate water purifier equipment was installed, after consideration of and comparison with lime-soda, hot process and zeolite systems. After several months operation, the equipment is meeting the guarantees by a very wide margin, even though operated at 40 per cent above its rated capacity.

For the purpose of purification of the mill condensate, which contains much oil, the same equipment is employed with the addition of a small tank and control equipment for permitting the addition of aluminum sulphate. When treating this oily water return, the equipment is operated at about 60 per cent above its rated capacity and is functioning perfectly.

Following the purification of raw water is the further treatment of this water in double-effect evaporators. As circulating water for the barometric condenser on the second-effect evaporator, the returns from the main condenser and from the mills (purified) are used. The discharge of this condenser is directly into the feedwater storage tank and thus the heat in the steam used in the evaporation process is almost entirely conserved. This virtually limits the cost of evaporating make-up water to labor of attendance and fixed charges.

FIG. 5. AUTOMATIC COMBUSTION CONTROL IS PROVIDED FOR THE BOILERS

From the feedwater storage, the water passes into a deaerating heater before being used in the boilers.

### Condensate Heat Is Utilized and Make-Up Evaporated

Steam for the evaporators and the deaerating heater is extracted from the turbine, along with the process steam for the mills, at 20 lb. pressure, provided that the supply from the few turbine-driven auxiliaries is insufficient for the demand of these units.

Provision has been made to cool the circulating water for the evaporator's condenser, by means of a closed cooler, in case this water which is mill and turbine condensate is too warm and limits the capacity of the evaporators. Advantage will be taken of this cooler principally when it is desired to increase the capacity of the evaporators and not because of limitation of capacity on account of excessive temperature of this circulating water.

Storage of feedwater is arranged in rectangular wells on the north side of the building. No. 1 well is used at present to store the condensate returns from the mills which is oily and needs purification. No. 2 well is the storage of water from the second-effect evaporator, the condenser and the over-flow from No. 3.

The latter is used to receive purified condensate from the mills, condensate from the main condenser and from the evaporators and drips from the steam lines that are not contaminated. From this well, the circulating water supply for the evaporator condenser is taken.

Capacity of feedwater storage wells is approximately 75,000 cu. ft. After the mill dryers and pipe lines have been cleaned and are free from oil so that no treatment is necessary for mill condensate, No. 1 well will be used for the same purpose as No. 2. These wells have a hollow tile insulating wall around the outside where heat could be conducted away into the adjacent soil. Otherwise no provision is made for their insulation.

### Coal Storage and Preparation

Coal is received in hopper bottom cars on a track built for delivery of coal to the power house. The coal is dropped from the cars into a hopper under the track and is carried by automatic skip-hoist to the top of the coal tower where each bucket full is deposited into a small hopper. A reciprocating plate feeder delivers it to a crusher, thence to a cylindrical storage tank. The skip hoist has a capacity of 50 t. per hr. and the tank a storage capacity of 100 t. From the storage tank a 2-t. weigh-larry, electrically driven, delivers coal to the hopper over the pulverizers.

Outside coal storage is handled by a drag line scraper of 35 t. per hour capacity, provision being made for storage of 5000 t. in the open. The storage yard is so located with respect to the hoppers over the pulverizers that, if the coal handling equipment fails, coal can be delivered from storage by wheelbarrows directly to the pulverizer without hoisting to the boiler room floor.

Coal used at this plant comes from West Virginia and a sample shows the following analysis:

| Proximate analysis: | Per Cent | |
|---|---|---|
| Air drying loss | 0.56 | |
| Moisture at 105 deg. F. | 0.23 | |
| Volatile matter | 37.48 | |
| Fixed carbon | 54.09 | |
| Ash | 7.14 | |
| Sulphur | 1.83 | |
| B.t.u. | | 13,939 |
| Fusion temperature of ash— | | |
| Initial | 2185 | deg. F. |
| Final | 2354 | deg. F. |

| Ultimate analysis | Per Cent |
|---|---|
| Carbon | 68.12 |
| Hydrogen | 5.35 |
| Oxygen | 16.90 |
| Nitrogen | 1.13 |
| Ash | 6.93 |
| Sulphur | 1.57 |

### Economizers and Air Preheaters Used

In developing the boiler equipment layout, it was decided to use a Stirling type boiler of approximately 6000 sq. ft. surface, to build a furnace chamber that would permit burning about 7000 lb. of coal an hour, to add an economizer for increasing feed water temperature and an air preheater to improve combustion. Both of the latter were justified, also, on the basis of earnings on the investment. The furnace chamber was designed for relatively high heat liberation, and water walls were installed in the hottest zone.

### Furnaces Arranged for Both Coal and Oil

Both stoker and pulverized fuel firing were given careful consideration, with the decision in favor of pulverized fuel because of certain advantages in banking losses, ready response to fluctuating demands, retarding corrosion trouble in the air preheater from sulphur in low temperature flue gases. Selection of the type of pulverizing equipment, the Bonnot mill of 7000 lb. capacity, was made on the basis of dependable continuity of operation, other factors having less weight in the decision.

Firing under the mud drum permitted of large combustion space and long flame travel within a minimum

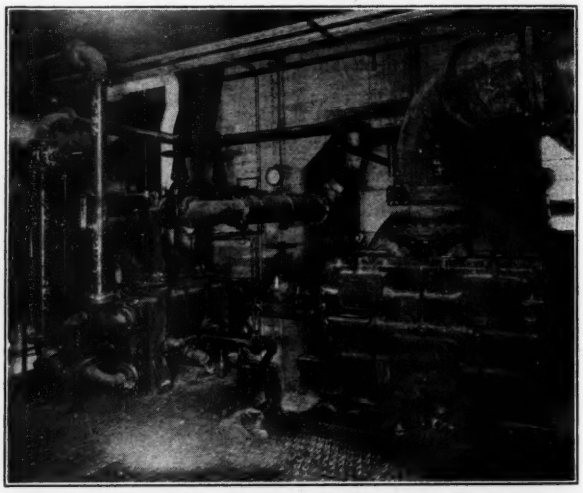


FIG. 6. TWO-STAGE, TWIN STEAM JET VACUUM PUMPS ARE SERVED BY A COMBINED INTER AND AFTER COOLER

floor area and was conducive to compact arrangement of the entire boiler equipment.

Water walls covered with refractory material were selected for several reasons, one being the low rating at which these units would operate during Sunday and holiday periods. The lower part of the water wall in the rear is carried out far enough to shade the ash pit and prevent fusion of ash deposit.

For the purpose of lighting off, a marine type of oil burner was installed, hung on hinges so as to swing out when not in use, a refractory plug, also on hinges, being swung into place in its stead. This burner is also used when the demand upon the boiler is below 20,000 lb. of steam an hour, such as for heating requirements during Sunday and holiday periods. Its operation permits shutting down the pulverizer, the exhauster and the forced draft fans and is resorted to for economic reasons.

Necessary oil storage tanks of ample capacity with oil pumps and heater were included and located as shown. Steam syphons are installed and operate periodically, as required, to remove water that settles out of the oil during the storage period. The oil is

transferred from cars on the coal track into the tanks by gravity, the necessary weatherproof vents being installed.

General arrangement of the boilers and superheaters with air preheater, economizer, water walls, forced induced draft fans and pulverizing equipment is shown in Figs. 3 and 4.

### Ash Is Sluiced Away for Filling

For ash removal, a sluicing system is used, the ash emptying into a pit and being transferred by a manganese pump to the south yard where a large area is to be filled. The fly ash that collects in the last pass of the boiler and under the economizer and air preheater is similarly handled. One hopper with division wall collects the ash from both zones and permits the same sluicing equipment to be used for both.

On account of the high water from floods and the elevation of the ash sump, it was necessary to resort to the use of this pump. The sluicing of the ash is also conducive to a clean plant and assists materially in reducing the dust that might find its way into the warehouses where the pulp is stored. Water supply is obtained from the fire pumps which are therefore given frequent check as to condition for fire use.

### Fuel and Air Control Are Automatic

While the fluctuations in demands for steam are not serious, it was considered desirable to use an automatic control for the boiler equipment to assure a more constant highly efficient operation. In addition, the equipment is located over four different floor elevations and automatic combustion control eliminates some boiler room labor.

Control equipment governs fuel feed to the pulverizer and from pulverizer to burner, the secondary air to the burner, the induced draft fan, the ratio of coal to air and the excess pressure of water into the economizer. Provision is also made automatically to shut off the supply of fuel to the burner in case of failure of the induced draft fan.

Gases discharged from the induced draft fans pass into short steel stacks 35 ft. in height. Provision was made in the supporting structures to permit additions to these stacks, if such is found desirable.

### Process Steam Control

Turbine generator units are equipped with special governors to give close regulation suitable for paper mill work, the extraction at 20 lb. being automatically controlled through this governor while the extraction at 50 lb. is taken care of by an outside reducing valve.

Superheat in the steam from the boilers was based on the condition of the steam at the 20 lb. extraction point. It was desired to have at least 25 deg. F. of superheat in this extracted steam, so that, when the latter reached the mills at the point of use, it would still be dry. For the purpose of adjustment and due to variations in the cooling of the steam through the delivery pipe lines, a slight amount above this was necessary. Desuperheaters were, therefore, installed to maintain automatically the superheat at the desired amount. The same arrangement was made with respect to the steam delivery from the 50-lb. line.

Desuperheaters in the 20-lb. line are of the surface type, using condensate from the main condensers for the cooling medium, while the desuperheaters in the 50-lb. line are of the spray type with necessary separating chamber, using boiler feedwater taken from the first stage of the boiler feed pumps. Both are thermostatically controlled.

### Cooling Water Supply

For supply of circulating water to the condensers, a line from the intake of the water wheel leads directly to a cold well located at the northeast corner of the power house building, as shown on Fig. 2. This is a gravity supply but, for a few days each year when the canal is out of commission, the supply is received from a pump house at the river through a pipe line which delivers into the same cold well. With this arrangement the conditions for the condenser circulating pump are the same at all times.

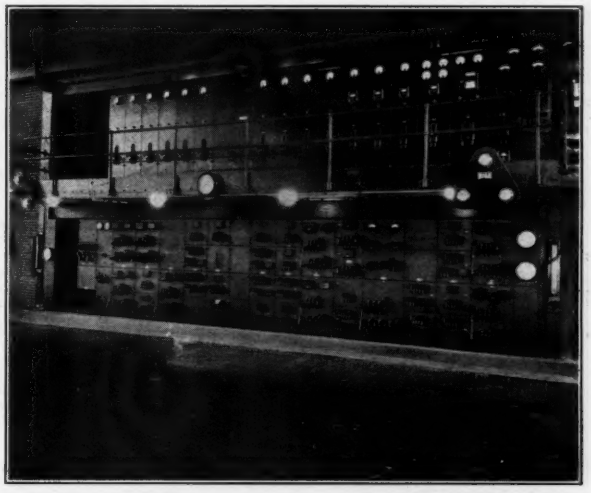


FIG. 7. ELECTRICAL CONTROL EQUIPMENT IS GROUPED TOGETHER AT THE END OF THE TURBINE ROOM

Advantage was taken of the hydraulic head by carrying the condenser discharge line back to the tail race and submerging the end. About 15 ft. is the average gross head available. The actual work of the circulating pump is to overcome about 3 ft. of static head and the friction through the condenser and pipe lines.

Originally, it was planned to allow the water to flow by gravity through the circulating water system. This was abandoned, however, because it involved too deep an excavation for the power house to secure the proper elevation of the condenser and also because the gross head available was reduced a few days a year by high back water in the tail race, necessitating the use of pumping equipment.

In the cold well are located screens of 5/8-in. mesh to guard against materials entering the smallest tubes in the air coolers. In order to keep these screens clean, the cold well was divided into two parts, either of which will be capable of handling water requirements for two turbines. When the screens require cleaning, one compartment is shut off, emptied and the screens back-washed with a stream of water under 75 to 150 lb.

# Principal Mechanical Equipment of Paul A. Sorg Paper Co. Power Plant

### GENERAL

Owner.....Paul A. Sorg Paper Co.
Location .....Middletown, Ohio
Service..Process steam and electric power
Designer.....Warren D. Spengler, Inc.

### BUILDING

Excavation, 7317 cu. yd.....
.....Middletown Sand & Gravel Co.
Concrete, 4649 cu. yd.....
.....Swingle & Robinson
Reinforcing steel, 215 t....Pollak Steel Co.
Structural steel, 409 t....T. H. Brooks Co.
Subway grating.....Irving Iron Works
Brickwork .....E. L. Frisch
Sash—rough actinic glass.....
.....David Lupton's Sons Co.
Doors—tinclad and kalamein.....
.....Durbrow & Otte
Roof slag, 3-in. Hoge, monolithic gypsum slab.....Lathrop-Hoge
Roofing and waterproofing, Barrett, 20-yr. bonded.....Falson & Davies
Ventilators, 36-in. with louvre dampers
.....The Swartwout Co.
Plumbing and downspouts..John Arpp Co.
Traveling crane, hand power, 10-t. capacity .....
....Cleveland Crane & Engineering Co.

### BOILER AND COMBUSTION EQUIPMENT

2 Boilers: Stirling water-tube, each 579-hp., 415 lb. working pressure, 5790 sq. ft. heating surface.....
.....Babcock & Wilcox Co.
Furnace arches and walls.....
.....McCabe Construction Co.
2 Bailey water walls, each 530 sq. ft.
.....Babcock & Wilcox Co.
2 Superheaters, rated 250 deg. at 300 per cent.....Babcock & Wilcox Co.
2 Economizers, 2969 sq. ft. each heating surface.....Babcock & Wilcox Co.
2 Air preheaters, heating surface each 7350 sq. ft.....Babcock & Wilcox Co.
2 Coal pulverizers, Fuller Lehigh Bonnot Mill No. 7; drive, 60-hp. squirrel cage GE motor.....
.....Babcock & Wilcox Co.
2 Exhausters, Fuller Lehigh, cast-iron; drive, 25-hp. GE turbine.....
.....Babcock & Wilcox Co.
2 Pulverized coal burners, Bailey-"Turbulent" forced draft type....
.....Babcock & Wilcox Co.
2 Secondary air fans, Green Fuel Economizer make, each 11,300 c.f.m., driven by 40-hp. slip ring GE motor.....Babcock & Wilcox Co.
2 Induced draft fans, Green Fuel Economizer make; each can handle 85,000 lb. gas per hr. at 450 deg.; each driven by 75-hp. squirrel cage GE motor.....Babcock & Wilcox Co.
2 Oil burners, San Diego.....
.....Babcock & Wilcox Co.
1 Fuel oil supply pump, 4 g.p.m., driven by 5-hp. squirrel cage GE motor...
.....Quimby Pump Co.
1 Oil heater, heating surface 72 sq. ft.
.....Andale Engineering Co.
2 Oil strainers .....
.....Andale Engineering Co.
2 Oil tanks, capacity each 9 by 33 ft.
..... Witt Steel Co.
Soot blowers .....
.....Diamond Power Specialty Co.
2 Stacks, size 54 in. diam. by 30 ft. high
.....Babcock & Wilcox Co.

### FUEL AND ASH HANDLING EQUIPMENT

Coal handling equipment.....
.....Freeman Riff Co.
Concrete track hopper, 12 by 14 by 7 ft. deep
Concrete auxiliary reclaiming hopper, 6 by 6 ft.
Automatic skip hoist, capacity 50 t. per hr.
Skip hoisting machine, 150 f.p.m.; drive, 25-hp. GE motor
Receiving hopper, capacity 150 t. cu. ft. of coal
Reciprocating feeder to crusher, 20 in. wide, 18 in. high
Crusher, spring relief type; drive, 20-hp. GE motor
Steel storage bin, capacity 100 t.
Automatic larry car, capacity 2 t.; drive, 7½-hp. GE motor, high torque, slip ring
Power drag scraper system; Drive 30 hp. squirrel cage, G.E. motor.....
.....Sauerman Bros.
Storage area, arc 40 deg.; maximum radius, 350 ft.
Drag scraper, handling capacity 35 to 40 t. per hr.
Scraper bucket, capacity 1 cu. yd.
Ash handling equipment.....
.....Allen-Sherman-Hoff Co.
Hydro-jet sluicing system
Water quantity, 375 g.p.m. at 100 lb. pressure
Fly ash gate.....Allen-Sherman-Hoff Co.
Ash pump, 4-in. American manganese; capacity, 425 g.p.m.; drive, 25-hp. squirrel cage GE motor.....
.....Allen-Sherman-Hoff Co.

### INSTRUMENTS AND CONTROL

Combustion control.....Smoot Engrg. Co.
Boiler feed meter, simplex venturi type.....Simplex Valve & Meter Co.
Draft gage, three-pointer.....
.....Ellison Draft Gage Co.
Conductivity recorders.....
.....Leeds & Northrup Co.
Boiler temperature recorders.....
.....Leeds & Northrup Co.
Thermocouples.....Leeds & Northrup Co.
Temperature recorders...The Foxboro Co.
Flow meters...The Brown Instrument Co.
Pressure gages.....
American Schaeffer & Budenberg Corp.
Indicating thermometers.....
.....Taylor Instrument Cos.

### GENERATING EQUIPMENT AND AUXILIARIES

2 Turbo-generators, each 5000 kw., 3600 r.p.m., condensing-extraction type extracting at 20 and 50 lb., the 20-lb. regulated by grid valve, the 50-lb. regulated by reducing valve; 3-phase, 60-cycle, 6600-v., separately excited.....General Electric Co.
2 Exciters:
1 Motor generator set, 75kw., squirrel cage motor drive..General Electric Co.
1 Dual driven generator set, 75 kw.; 110-hp. squirrel cage motor; 110-hp., 440-v., 1200-r.p.m., 3-phase, 60 cycle, GE turbine..General Electric Co.
2 Air coolers, cooling surface 3500 sq. ft. each.....General Electric Co.
2 Oil coolers, cooling surface 220 sq. ft. each.....Andale Engineering Co.

### CONDENSING EQUIPMENT AND AUXILIARIES

2 Surface condensers, each 6000 sq. ft.
.....Westinghouse Elec. & Mfg. Co.
2 Steam jet air pumps, Le Blanc.....
.....Westinghouse Elec. & Mfg. Co.
Inter and after surface condenser, 21.09 cu. ft. of 70 deg. free air per min.
1 Condensate pump, capacity 220 g.p.m., motor drive.....
.....Westinghouse Elec. & Mfg. Co.
2 Circulating pumps, capacity each 5000 g.p.m., 30hp. slip ring GE motor driven.....Dean-Hill Pump Co.

### SWITCHING EQUIPMENT

6600-v. control board.....
.....Westinghouse Elec. & Mfg. Co.
2 Turbine panels, 2 exciter panels, 1 totalizing panel, 1 house feeder panel, 3 mill feeder panels, 2 blank panels.
Equipment:
6 Westinghouse type E16 600-amp., 15,000-v., solenoid-operated oil breakers
3 Sets of lightning arresters, Westinghouse type SY indoor auto-valve arresters used on mill feeders.
Cell structure furnished and erected by
.....Deceleco, Incorporated
Storage battery, 60-cell electric storage battery E7, enclosed type.....
.....Westinghouse Elec. & Mfg. Co.
Motor-generator set for battery charging, 1½-kw., 140-v., shunt wound, d.c. generator., drive 3-hp., 440-v., 3-phase, 60-cycle induction motor.
1 Battery control panel.
440-Volt station distribution board, 16 panels, 440-v. push button control, motor starting switchboard for house auxiliaries..General Electric Co.
Distribution lines:
2 2500-kv.a. feeders to Smith & Oglesby mills, 6600-v.
1 3000-kv.a. feeder to Sorg mill, 6600-v.
1 600-kv.a. feeder to station, 660-v.
GE cable, 3-conductor, lead-armored, 15,000-v. insulation, run underground to the mills.
GE cable furnished through Post-Glover Division, installed by.....
.....Chas. M. Kelso Co., Inc.
Transformer banks, 6900-480-v., self-cooled, outdoor type.....
.....Pittsburgh Transformer Co.
2 banks of three 833-kv.a., single-phase transformers for Smith & Oglesby.
1 bank of three 1000-kv.a., single-phase transformers for Sorg.
1 bank of three 200-kv.a., single-phase transformers for Powerhouse.
440-volt distributing feeder control at transformer banks.....
.....Westinghouse Elec. & Mfg. Co.
3 300-amp., 440-v., 3-pole, single-throw, solenoid-operated, Westinghouse type B6 oil switches, remote control from power house.

### WATER TREATMENT AND HEATING EQUIPMENT

1 Water softener equipment, lime barium carbonate water softener, capacity 3000 g.p.h.....
....Reisert Auto. Water Purifying Co.
1 Water softener pump, 100 g.p.m.; drive, 5-hp. squirrel cage GE motor
.....Dean-Hill Pump Co.
1 Electric hoist, capacity 1000 lb.....
.....Chisholm Moore Co.
1 Deaerating heater, Cochrane direct contact.....Dravo Doyle Co.
Working press., 25 lb. gage; capacity, 150,000 lb. per hr.; water storage, 75 cu. ft.; tray surface, 162 sq. ft.; heating surface of vent cond., 150 s. ft.
1 Evaporator, 700 sq. ft. evaporating surface, return bend, submerged type, double effect.....
....Wheeler Condenser & Engrg. Co.
1 Circulating pump for evaporator, 200-g.p.m.; drive, 5-hp. squirrel cage GE motor...Dean-Hill Pump Co.
1 Heat interchanger, surface type, 116 g.p.m. of water from 200 to 135 deg. F. when supplied with 230 g.p.m. of cooling water at a temperature of 75 deg. F.....
.....Andale Engineering Co.
1 Barometric condenser head.....
.....Wheeler Cond. & Engrg. Co.

### PIPING AND VALVES

3 Desuperheaters on 20-lb. line to mill
.....Andale Engineering Co.
Temperature regulators...Sarco Co., Inc.
2 Desuperheaters on 50-lb. line to mill double spray type.....
.....Schutte & Koerting Co.
High and low pressure steam piping
.....M. W. Kellogg Co.
Pipe covering.....
....Asbestos & Magnesia Material Co.
Water supply piping: 24-in. line from hydraulic, bell and spigot; 16-in. line from river, universal joint....
.....John Arpp Co.
Gate valves.....Chapman Valve Mfg. Co.
Globe valves....Edward Valve & Mfg. Co.
Relief valve on 50-lb. line.....
.....Ashton Valve Co.
Pressure reducing valve.....Foster
Atmospheric relief multiport valve on 20-lb. line.....Cochrane Corp.

### BOILER FEED AND OTHER PUMPS

1 Boiler feed pump, 250 g.p.m.; drive, 150-hp. synchronous GE motor....
.....Dean-Hill Pump Co.
1 Boiler feed pump, 250 g.p.m.; drive, 130-hp., non-condensing GE turbine
.....Dean-Hill Pump Co.
2 General service pumps, 200 g.p.m., drive, one 20-hp., one 25-hp. squirrel cage GE motors...Dean-Hill Pump Co.
2 Fire pumps, 750 g.p.m.; drive, 75-hp. squirrel cage GE motor.....
.....Dean-Hill Pump Co.
2 Heater pumps, 250 g.p.m.; drive, 15-hp. squirrel cage GE motor.....
.....Dean-Hill Pump Co.
1 Sump pump, 50 g.p.m.; drive, 1½-hp. squirrel cage GE motor.....
.....LaBour Pump Co.
1 Centrifugal, vertical pump, 5000 g.p.m.; drive, 100-hp. squirrel cage GE motor.....Dean-Hill Pump Co.

### HYDROELECTRIC PLANT

Excavation, 2111 cu. yd.....
.....Middletown Sand & Gravel Co.
Concrete, 600 cu. yd...Swingle & Robinson
Reinforcing steel, 30 t....Pollak Steel Co.
Brickwork .....E. L. Frisch
Sash, rough actinic glass.....
.....David Lupton's Sons Co.
Doors.....Durbrow & Otte
Roof, 3-in. Hoge-monolithic gypsum slab .....Lathrop-Hoge
Roofing and waterproofing, Barrett, 20-yr. bonded.....Falson & Davies
1 Hydraulic turbine unit, 36-in. type S vertical turbine, 180 r.p.m.; governor, type HR Woodward oil pressure.....The James Leffel & Co.
Generator, vertical type, direct connected exciter, capacity, 350-kw., 480-v., 3-phase, 60-cycle.....
.....General Electric Co.
Switchboard consists of 4 panels for automatic control..General Electric Co.

pressure. A platform and door opening from the turbine basement permits an operator to back-wash these screens from the discharge side of the screen, an arrangement which has proven satisfactory as well as inexpensive.

If needle ice forms during the winter months and tends to foul the screens, provision is made to recirculate the condenser discharge water or a part of it to melt the ice. This is the reason for carrying the discharge line through the chamber of the cold well.

Provision is made also for overflow from the cold well when shutting down the circulating pumps, this overflow going directly into the tail race through the same line that takes the wash water from the screens.

Condensers have a normal capacity of 40,000 lb. an hour with 70 deg. F. water, which will enable them to condense about 70 per cent of the full condensing load. Usually, at full load, there is extracted about 60 to 65 per cent of the throttle flow, leaving about 40 per cent to be condensed. No possible unbalance of operating conditions will necessitate a capacity greater than that allowed for.

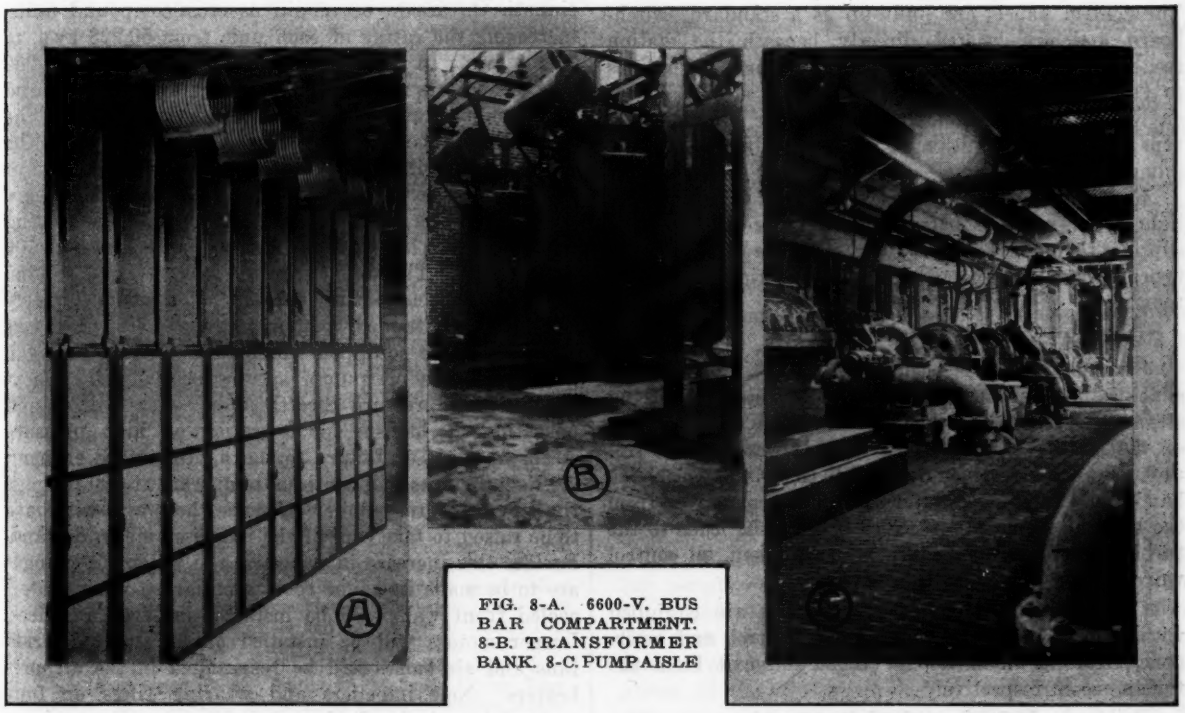


FIG. 8-A. 6600-V. BUS BAR COMPARTMENT. 8-B. TRANSFORMER BANK. 8-C. PUMP AISLE

### Condenser Auxiliaries

As usual a condensate pump is installed, with the provision that a supply of additional condensate can be obtained from the feedwater storage tanks and, if necessary, after it has been cooled through the evaporator condenser cooler, mentioned above. This provision is necessary when, as on Sundays in winter, the condensate is insufficient for water supply to the oil cooler. The supply line feeds directly into the suction side of this pump.

Air ejector equipment is standard, except that a part of the condensers receive cooling water from the main condenser pump and the other part from the condensate pump. This arrangement is necessary because the usual amount of condensate is insufficient to accomplish the full amount of work, due to the large quantities of steam extracted. At the same time, it was desirable to reclaim as much heat as possible from the ejectors. The circulating pump is, of course, suitable for the size of the condenser but on account of the head from the hydraulic canal the size of the motor is about fifty per cent of that otherwise required.

Air coolers under the generators receive cooling water also from the main circulating pump, the correct amount being obtained by throttling the control valve, inasmuch as the friction head through the coolers is about 45 per cent of that through the main condenser. The discharge from these coolers as well as from the air ejector condensers is piped back into the main discharge line from the main condenser.

Whenever the turbines are shut down and steam is required at 20 lb. pressure for the mills, provision is made for reducing the main 400-lb. pressure steam to 20 lb. Two stations are used, one reducing from 400 to 50 lb. and one reducing from 50 to 20 lb. After each reduction, the steam passes through the regular desuperheaters for reduction of superheat.

Main generators deliver power at 6600 v., 3 phase, 60 cycles to the main bus, from which power is taken to the mills through armored underground cable and to the station transformer bank. The latter is of sufficient capacity for future requirements, i. e., three boilers and two turbine generators in operation.

For the protection of the generators, the six terminals of the winding are brought out through current transformers and differential relays are installed to operate on the generator circuit breakers. The control

is so arranged that, if this action takes place, the load cannot be thrown on to the small hydroelectric generator, although this continues to supply power to the station auxiliaries.

All auxiliary equipment is motor driven, except the exhausters on the pulverizers, the one turbine driven boiler feed pump and the one dual-driven exciter. The exhausters are turbine driven to give ease and accuracy of control of coal feed to the furnaces. The other two turbines were installed as protection, the former against failure of water supply to the boilers and the latter against shutdown due to low voltage on the station bus.

All motors are equipped with push button control. The control panels are built up as a standard switchboard and are located directly beneath the station feeder switchboard, which permits of short feeder lines to the control panels. This location is clearly shown on Fig. 3. In addition, fire pumps have the approved type of starting equipment located adjacent to the pumps.

For control of the 6600-v. switches and for emergency lighting, a suitable battery with motor-generator set supplies the power. This battery is of the trickle charge type, designed for installation and operation in an open room.

### Steam Pipe System

Station piping has been laid out as simply as possible, the high-pressure leads from the boilers delivering steam into a receiver header located in the basement of the turbine room. An automatic drainage control unit keeps this receiver dry at all times and is able to handle any amount of water that might come over from the boilers. From this receiver header, the leads to the turbines and auxiliary equipment are taken, all control valves being located at this receiver.

Control valves at the boiler outlets are equipped with motor operating devices with control and emergency stations in the boiler room and exit from the turbine room respectively.

Boiler feedwater supply is arranged on the ring system basis for obvious reasons. Both the high-pressure steam and boiler feed lines have tongue and groove connections. A low-pressure 20-lb. header is located in the boiler room to receive exhaust from the auxiliaries and to supply steam to the evaporators and deaerating heater. A cross connection is made to the 20-lb. header into which turbines discharge the 20-lb. extracted steam and from which the mill lines receive steam supply.

In the basement the water lines are carried under the floor and above the concrete mat so that the space around pumps and other equipment is free of all piping. Provision in the condenser piping is made for circulating hot water through the condenser for cleaning tubes, a special solution being put into the condenser for this purpose.

Process steam lines to the mills and the return condensate lines are led through tunnels from the power house to the Smith and Oglesby mills and underground to the Sorg mill in Ricwil piping.

All piping is properly covered, with special material used where high temperatures are encountered. All hot air ducts are also covered.

Complete equipment of indicating, integrating and graphic recording instruments enables the operating force to watch the operation of all machines and keep the plant in the best condition possible. The condition of feedwater is checked daily and its contamination can be detected at various points. Concentration tests of boiler water are included in these daily observations.

## Columbia System Increases Generating Capacity

TWO TANDEM COMPOUND UNITS with boiler reheat between the high and low-pressure elements at Columbia Station of the Columbia Power Co., Cincinnati, O., are to be rebuilt as cross-compound units, increasing the rating of each unit from 50,228 kv.a. to 76,800 kv.a. In rebuilding these units, two of the 31,250 kv.a. generators now at West End Station will be moved to Columbia Station and two new high-pressure turbine elements will be installed with these generators. The rebuilt units will each have a capacity of 61,000 kw. at 75 per cent power factor. The present high-pressure elements will be removed. Under the present operating conditions, the low-pressure elements take steam at 100 lb. pressure. This inlet pressure will be raised to 185 lb. gage, in order to carry the generator rating formerly carried by the tandem-compound unit. The low-pressure element will be equipped with a new bearing pedestal, governor drive oil pump, speed and emergency governors, high pressure throttle valve with control and operating mechanism for operation on high pressure steam in event of failure to the high-pressure element.

Rebuilt units will continue to operate at 600 lb. gage throttle pressure. Boiler pressure, however, will have to be raised to take care of the increased steam demand. Besides this increase in pressure, the following changes are to be made in boiler room auxiliaries. New water-cooled front walls will be installed in seven furnaces. Larger motors will be installed on all induced draft fans and air baffles will be rearranged in the air preheaters. New impellers and wearing rings on four motor-driven boiler feed pumps, new governor weights to increase speed of two turbine-driven boiler feed pumps, installation of two new motor-driven boiler feed pumps and the addition of two evaporators will complete the changes in the feedwater system. A new 70-in. pulverizer mill will be installed to handle the increased coal consumption. These changes in boiler room equipment will increase the individual boiler output from 160,000 lb. per hour to 200,000 lb. per hour.

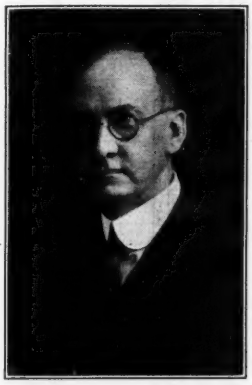
At West End Station, the four 31,250-kv.a. generators will be removed and replaced by four new 45,000-kv.a. generators. In order to carry this increased rating, two of the turbines will have new first-stage nozzles and diaphragms for stages two to 10, inclusive, and a cast-steel diaphragm for the 11th stage. The other two turbines will have new diaphragms for stages 6 to 10, inclusive, and a cast-steel diaphragm for the 11th stage. Three of these turbines will have new and heavier couplings, guide brackets between turbine head and oil tank, also between turbine head and bearing cap and four turbines will be equipped with new primary and overload cams and holders. This station will continue to operate at 250 lb. gage at 600 deg. F. total temperature. An additional motor-driven boiler feed pump and four extraction feedwater heaters will be installed.

# Cost and Performance of Industrial Plants

SIMPLE REPORTS WITH INSTRUMENT RECORDS TELL THE STORY. BY HUBERT E. COLLINS

UNLESS the engineer can be raised to a professional status, he will remain on a job. It is also true that, if a man continues operation of any industrial power plant on a job level, he is headed for trouble.

Time was when the engineer and owner were nearly on a par and understood each other's habits and methods of thought. The mechanico-steam-engineer of 50 yr. ago was comparable to the "Village Blacksmith" working "neath the spreading chestnut tree" and he commanded the admiration and respect of every other man in the community. Engineer and owner were nearer a financial balance.



Now the Boss has learned to talk dollars and cents. Nothing will interest him more than the explanation of how to make a dollar, unless it be knowledge of how much that dollar will purchase or what portion of it he must spend to get another. We all love to be thought of as practical and, in this, the Boss is normal and to be classed as other men.

HUBERT E. COLLINS, consulting engineer, Utica, N. Y., began work with the Lake Erie Engineering Works of Buffalo in 1890. After serving as erecting engineer for several years, he became secretary of Ambrose Machinery Co. and later vice president of Engineering Supervision Co. For 25 yr. he has practiced as consulting engineer on power plant installation and operation, achieving distinction also as a writer for technical journals and an author of books, both technical and historical. He is member and has been officer of technical and historical societies, including New York State Association Power Engineers, Mohawk Valley Engineers Club, Federated Engineering Council, Societe Academique d'Histoire Internationale of Paris, Colorado Historical Society.

### INDEPENDENT PLANT ENGINEERS NEED FACTS

Many industrial engine rooms, which have not changed physically, can still keep pace with others in expense of a manufactured boiler horsepower or kilowatt-hour delivered "on the hoof." Within its capacity range, we have found that the fire-tube boiler can equal the water-tube in economy. The steam engine is good equipment in a factory requiring process steam. Mouth-of-the-mine and white-coal plants have been duly appraised and found no better than other combinations for serving the majority of industrial plants. All this has been proved during the years and yet the operating engineer has not maintained a professional position in industrial power plants.

The engineer needs calm, honest self-analysis and prompt action on his findings. Acknowledging the materialistic trend of the times, he must first admit that the boss is most interested in a businesslike administration of the power plant which will prove it on a level with every other department in his works. Salvation lies in an effort again to reach the regard of the Boss. He will be interested in worth while suggestions of new methods connected with power production.

If the operating engineer desires to remain an independent head of his department, he must study such subjects as Selection and Training of Personnel, and realize that there must be thorough schooling in the rudiments of the "profession." There must be a training apprenticeship which will fit for and raise the requirements to equal those for the mechanic-engineer who first won respect for the profession.

He may well adopt a suggestion system and receive helpful hints from his assistants and those in other departments. He must snap out of the isolation and keep in touch with progress.

Bonus record systems have been and are successfully operating in power plant boiler rooms. Such plans need only a little study to start and a few trials to reach a satisfying success. In some instances, similar plans can be used in the dynamo and engine room. No greater contentment can be secured with the hard-working crews in blistering boiler rooms, than by a well applied bonus.

### RECORDS ARE THE BASIS OF PROGRESS

Start on the upward trail must come through keeping simple records of power plant performance, for study and as a basis of daily reports to the main office. The first production of such a report will arouse the interest of the Boss and he will show it by a pleased gleam of the eye where before was dull listlessness. After the first report arouses interest, it is easy to enlist the coöperation of the main office accountants. Some good natured one will have given the cost figures necessary to fill out the initial effort and can see possibilities for mutual aid in team work with the engineer.

With the first daily record in the process toward a report, the engineer has found his means of checking operation performances and comparing them with what he has seen in print. The accountant sees opportunity of checking amounts of supplies, contract work, labor, and the like in connection with the power and steam items. The Boss can see what he has wanted for many days,—total costs of everything in the power plant, itemized costs, total cost of the power item of manufacture and just what he gets in steam and power production for the money expended.

This is history as it happened in one plant and enthusiastic orders were given to continue daily reports by months for a year. The writer of this article was called in to give of his experience to further the idea of reports, and the result was a gradual evolving of a system of simple records and daily reports spread into a complete yearly performance. Sample forms are here shown that have been in use several years which will aid management in the power plant. These forms will

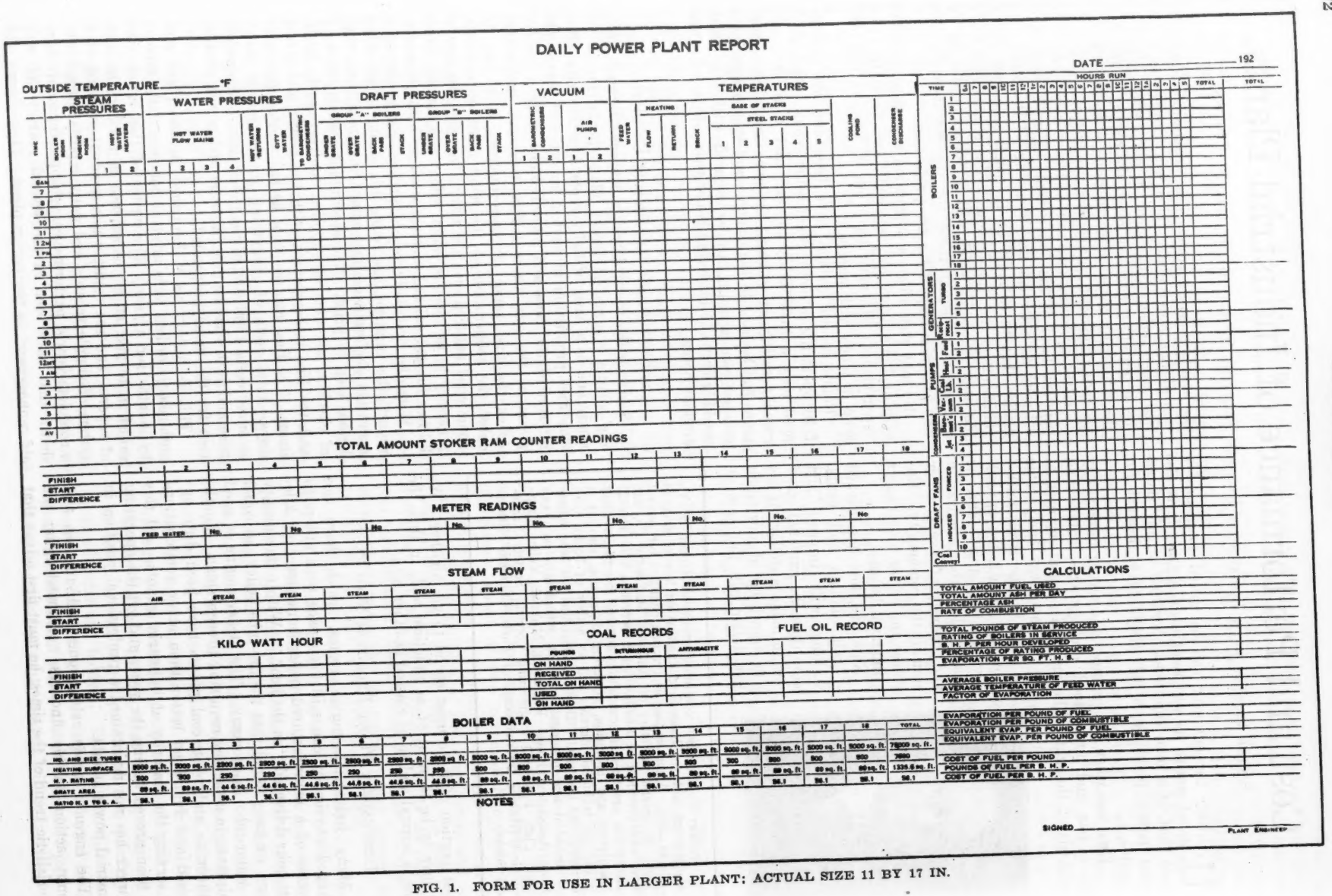



FIG. 1. FORM FOR USE IN LARGER PLANT; ACTUAL SIZE 11 BY 17 IN.

not be suitable in wording and other detail for all plants, but will serve as models.

### Requirements of Records

Experience with records has shown that simplicity not only aids in clear understanding but also makes them businesslike. The Boss likes them because they conform with his shibboleth. Everything connected with the daily reports should be pared and pared again to obtain just the necessary data with a minimum of for in these reports. This should be done for the sake of the greatest accuracy. Recording 24-hr. gages can be had for all steam, water, draft and vacuum pressures. All temperatures about a power plant can be gage recorded. The pressures and temperatures can then be entered on the report in proper columns, after taking on the recording instruments. (Totals at bottoms of columns may be all that need be transferred to the reports.)

Complete equipment of gages is sometimes more

DAILY POWER PLANT REPORT

OUTSIDE TEMP _____°F _____192____

| TIME | PRESSURES: STEAM: BOILER ROOM | ENGINE THROTTLE: 1 | 2 | 3 | RECEIVERS: 1 | 2 | 3 | HEAT SYSTEM | PLUE GAS: UNDER GRATE | OVER GRATE | STACK 1 | STACK 2 | WATER MAIN | TEMPERATURE: FEED WATER | PLUE GAS: STACK 1 | STACK 2 | VOLTAGE | HOURS RUN: ENGINES 1 | 2 | 3 | BOILERS 1 | 2 | 3 | 4 | 5 | AIR COMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.00 A. M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.00 P M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 4.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 10.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 A. M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AVER | | | | | | | | | | | | | | | | | | | | | | | | | | |

COAL RECORD: ON HAND; REC'D; TOTAL; USED; ON HAND

POWER METER: PRESENT; PREVIOUS; DIFF

LIGHT METER: PRESENT; PREVIOUS; DIFF

FEED WATER METER: PRESENT; PREVIOUS; DIFF

WATER METER: PRESENT; PREVIOUS; DIFF

GAS METER: PRESENT; PREVIOUS; DIFF

ASH REMOVAL: POUNDS

CALCULATIONS

| | | | |
|---|---|---|---|
| TOTAL FUEL USED | | AVERAGE TEMP OF FEED | |
| ASH | | FACTOR OF EVAPORATION | |
| PERCENTAGE ASH | | EVAP PER LB FUEL | |
| RATE OF COMBUSTION | | " " COMBUSTIBLE | |
| TOTAL POUNDS STEAM USED | | EQUIV EVAP PER LB FUEL | |
| RATING OF BOILERS IN SERVICE | | " " " COMBUSTIBLE | |
| B. H. P. PER HOUR DEVELOPED | | COST OF FUEL PER LB | |
| PER CENT OF RATING PRODUCED | | POUNDS PER B H R | |
| EVAPORATION PER SQ. FT. H S. | | COST " " " | |
| AVERAGE BOILER PRESSURE | | | |

BOILER DATA

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| SQ FT H S | 650 | 1300 | 1300 | 2500 | 2500 |
| RATING | 65 | 130 | 130 | 250 | 250 |
| SQ FT G A | 24 | 27 | 27 | 60 | 60 |
| RATIO H S TO G A | 35:1 | 48:1 | 48:1 | 42:1 | 42:1 |

SIGNED _____ Engineer

FIG. 2. FORM FOR USE IN SMALLER PLANT; ACTUAL SIZE 8½ BY 11 IN.

instruments and work. With this in mind, Figs. 1, 2 and 3 have been planned and in use several years, where the items on each are exactly sufficient for the needs.

If a report can be filed away in a standard letter size folder, it will be best. For that reason, Figs. 2 and 3 are planned to be printed on sheets 8½ by 11 in. Figure 1 or similar will be sheet size 11 by 17 in. It will go into a letter size folder after folding once in the middle.

If the reader will study these forms carefully, not much explanation is needed to make their use clear. When a power plant needs the addition of details not given on the sample forms, names or numbers of columns must be made to suit.

Recording gages can be had at reasonable cost for use in obtaining most of the desired information called than the owner wishes to purchase. In event of such a "hang up," the engineer can assure the Boss of a ten per cent saving in power plant expenses, simply through the medium of daily reports. (This will certainly be true when reports have never before been kept.)

Should there be good reason for non-equipment to record all data which goes into a report, most of the information can be gleaned from the regular indicating gage equipment by readings at regular hourly intervals placed on the report by men on watch.

### These Items Must Be Known

Three essential items of daily power plant operation must be secured or there is no use in keeping records. These items are amount of coal or other fuel burned, amount of steam generated, temperature of feedwater. Here lies the very basis of all calculations in reference

to any boiler plant, the amount of fuel burned and its value as an evaporator of water into steam. One must know these things or he will know nothing. To know them means that one can estimate the amount of fuel paid for, pounds of steam one pound of fuel will evaporate, pounds of fuel required per boiler horsepower-hour, the actual performance compared to what it should be. With the cost of the fuel from the accountant, the engineer can give the cost of fuel per 1000 lb. of steam evaporated, and per horsepower-hour. With these basic costs in hand, one can estimate performances and costs of every detail of power plant operation. There is

With the fuel information in hand, it is equally important to know the amount of steam evaporated by the fuel burned. This information can be had by measuring water fed into the boiler or boilers. Also it can be found by measuring the amount of steam leaving the boilers. Some plants use open-heater meters on the suction side of the feed pumps, others favor meters on the discharge lines. Flow meters are now reliable and can be used on feed lines with faith in their accuracy. A reasonable amount of checking will assure results. A flow meter on the steam discharge of the boiler is a good method, if blowoff valves are tight

MONTHLY ANALYSIS POWER PLANT REPORTS MONTH OF_____192__

| | BOILER ROOM | TOTAL | AVERAGE |
|---|---|---|---|
| 1 | POUNDS STEAM PRODUCED | | |
| 2 | BOILER HORSE POWER PRODUCED | | |
| 3 | BITUMINOUS COAL CONSUMPTION | | |
| 4 | ANTHRACITE COAL CONSUMPTION | | |
| 5 | AVERAGE FEED WATER TEMPERATURE | | |
| 6 | AVERAGE FLUE GAS TEMPERATURE (BASE OF STACK) | | |
| 7 | AVERAGE BOILER PRESSURE | | |
| 8 | AVERAGE FLUE GAS PRESSURE | | |
| 9 | AVERAGE FACTOR OF EVAPORATION | | |
| 10 | AVERAGE EVAPORATION PER POUND OF FUEL | | |
| 11 | AVERAGE EVAPORATION PER POUND OF COMBUSTIBLE | | |
| 12 | AVERAGE EQUIVALENT PER POUND OF FUEL | | |
| 13 | AVERAGE EQUIVALENT PER POUND OF COMBUSTIBLE | | |
| 14 | AVERAGE PERCENTAGE OF ASH | | |
| | CURRENT EXPENSES | | |
| 15 | COST OF FUEL DELIVERED TO STORAGE | | |
| 16 | COST OF FUEL DELIV'ED FROM STORAGE TO BOILER ROOM (COAL HANDL'G, LABOR & MOTOR) | | |
| 17 | TOTAL COST OF FUEL TO BOILER ROOM | | |
| 18 | WAGES OF FIREMEN AND WATER TENDERS | | |
| 19 | WAGES OF BOILER REPAIR MEN | | |
| 20 | WAGES OF LABOR AND FIREROOM ENGINEER (LEAVING OUT COAL HANDLING) | | |
| 21 | GENERAL SUPPLIES | | |
| 22 | REPAIRS (ASIDE FROM BOILER REPAIR WAGES) | | |
| 23 | LIGHT | | |
| 24 | POWER (ALL MOTORS IN BOILER ROOM) | | |
| 25 | GENERAL EXPENSES | | |
| 26 | DEPRECIATION (BALANCE OF 10% ON EQUIPMENT ADDED TO ITEM 22) | | |
| 27 | INSURANCE (FIRE) | | |
| 28 | INSURANCE (BOILER) | | |
| 29 | INSURANCE (EXPLOSION) | | |
| 30 | TAXES | | |
| 31 | STEAM FOR FEED PUMP | | |
| 32 | TOTAL COST OF STEAM PRODUCTION | | |
| 33 | COST OF COAL PER POUND | | |
| 34 | POUNDS COAL PER B. H. P. | | |
| 35 | COST OF COAL PER B. H. P. | | |
| 36 | TOTAL COST PER B. H. P. | | |
| 37 | COST OF EVAPORATION PER 1000 LBS STEAM | | |

NOTES

FEED PUMP OPERATION SUPPLIES AND REPAIRS TO BE INCLUDED IN ITEMS 20 22 27 30
FEED PUMP STEAM TO BE CHARGED AT COST PER 1000 LBS
MAINTENANCE, OPERATION, AND TAXES OF HEATING SYSTEM TO BE DEDUCTED AND CHARGED TO HEATING

| | ENGINE ROOM | TOTAL | AVERAGE |
|---|---|---|---|
| 1 | TOTAL KILO WATT HOURS PRODUCED | | |
| 2 | KILO WATT HOURS PRODUCED FOR LIGHT | | |
| 3 | KILO WATT HOURS PRODUCED FOR POWER | | |
| 4 | TOTAL STEAM USED FOR GENERATORS AND AUXILIARIES | | |
| 5 | KILO WATT HOURS PURCHASED FOR LIGHT | | |
| 6 | KILO WATT HOURS PURCHASED FOR POWER | | |
| 7 | TOTAL KILO WATT HOURS PURCHASED | | |
| 8 | AVERAGE VOLTAGE | | |
| 9 | AVERAGE WATER RATE PER KILO WATT HOUR | | |
| 10 | AVERAGE POUNDS COAL PER KILO WATT HOUR | | |
| | CURRENT EXPENSES | | |
| 11 | WAGES, ENGINEERS ATTENDANTS, LABOR (INCLUDING COOLING POND) | | |
| 12 | COST OF STEAM FOR GENERATORS AND AUXILIARIES | | |
| 13 | COST OF POWER FOR PUMPS AT COOLING POND | | |
| 14 | GENERAL SUPPLIES | | |
| 15 | REPAIRS | | |
| 16 | LIGHT | | |
| 17 | POWER | | |
| 18 | GENERAL EXPENSES | | |
| 19 | DEPRECIATION | | |
| 20 | INSURANCE (FIRE) | | |
| 21 | INSURANCE (EXPLOSION) | | |
| 22 | TAXES | | |
| 23 | TOTAL COST OF KILO WATT HOUR PRODUCTION | | |
| 24 | TOTAL COST PER KILO WATT HOUR | | |
| 25 | COST OF PURCHASED LIGHT | | |
| 26 | COST OF PURCHASED POWER | | |
| 27 | TOTAL OF PURCHASED CURRENT | | |

NOTES

ITEM 12 ESTIMATED AT RATE OF ITEM 37 IN BOILER ROOM

SIGNED_____
PLANT ENGINEER

FIG. 3. FORM FOR MONTHLY ANALYSIS OF POWER COSTS; ACTUAL SIZE 8½ BY 11 IN.

absolute necessity for instruments to get this essential information.

Weight of coal can be secured with so simple an apparatus as a platform scale and a wheelbarrow. Coal has even been weighed and measured in containers, then dumped and a score kept of the number of lots used, the total being entered on the report. Better still are weighing scales for discharge chutes from bunkers, or devices which will measure the coal going into storage or being fed. Where ram stokers are used, a notation of weight of coal pushed forward by each stroke of a ram and counters on the rams, makes an accurate combination for measuring fuel. Oil and powdered coal can be metered. But, however obtained, pounds of fuel used in the plant each day must be known.

and the readings of steam flow are paralleled by those of a recorder on the steam pressure and the feedwater temperature.

It may be well at this point to reiterate a clear, definite truth in reference to all automatic recording devices. No instrument is infallible. Like humans, they require regular inspection to keep them safely accurate. In other words,—when you put an instrument to work for you, do not expect it to function alone and always remain accurate. Check every day and, when readings are in doubt, inspect and find whether there is a disturbing element in the mechanism or connecting lines.

Reference to the daily report forms shows generous space allotted for record of various machine-hour runs such as engine, boiler and pump hours. These can be

graphically recorded with a pencil line drawn through the hours that the machine was in service from starting hours to closing time. As an illustration of the value of this, let the reader visualize a plant where several large pumps are in service regular hours during each day, week and year. Knowing that pumps use large amounts of steam, we want to know the amount used per year. Making a test of each pump in turn, we find what each uses per hour in pounds of steam; multiply by the number of hours graphically recorded for the year to get the total used. The same method applies to other machines.

### Boiler Equipment Records

Another item of the daily report forms is the boiler equipment records. These can well be augmented by a printed line giving dimensions of smokestack and all smoke breeching areas. With these latter data, the operator is enabled to analyze combustion in full detail.

Separate equipment record on typewritten sheets, augmented by building elevation and floor plans, should give the amount of radiating surface used for factory heating. Accompanying this should be estimates of floor areas and cubic content heated. These data should be distributed by departments, floors, buildings, and totaled.

Yearly reports will need the number of working days and hours served by the power plant. This information can come from the main office. The chief accountant should give the operating engineer all amounts paid out for the power plant and the sums will first appear on the monthly analysis and finally be summed up in the yearly report. In this connection, all amounts shown on the monthly analysis under current expenses should be included. Heating hours for the year can be gleaned from the heating system steam pressure, or heating system hot water temperature columns, of daily reports.

### Facts Are Needed to Meet Changing Conditions

In partial recapitulation the writer asserts that conditions have changed in industrial power plants to an unbelievable extent because the plant engineers have not sold their work to the owners. This is the cause of many industrial plants closing down and will clear the field of more independents unless facts are furnished. Being an old engine room man, he knows that, when the generating units of an industrial power plant are closed down and required current comes from the outside, the heart is taken from the man on the job. The office expresses it in the words, "There is a falling off in morale." The operating force has less to do, is not called into conference as formerly and there is a corresponding drop in cordial relations. Such conditions add to the paralyzing effects of poor management, which is now charged to the operator. Taken all around, there is a decided drop in self esteem of the engineer who was formerly in proud control. It is with the hope of relieving this situation that the daily reports, monthly analysis, and yearly reports are suggested.

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In several ways, man is unique on this earth. He invented hair dye, for example, and he scrubs his teeth. He discovered doughnuts and the derby hat and he beautifies himself by cutting off his whiskers. No other animal does these things.—Baker Brownell.

# Pressure Actuated Feedwater Temperature Controller

By Wm. P. Saunier*

FOR CONTROLLING the temperature of water in an open feedwater heater in central station service, the device described in this article was recently placed in operation and has given results in uniformity of temperature far better than other controllers have shown. The design of the apparatus was suggested by J. A. Powell, Mechanical Engineer of W. S. Barstow & Co., Inc., after many years' experience with various types of commercial temperature controls, which gave only partially satisfactory results and required continued care and adjustment. In fact, the results from automatic controls were such that several of the recent plants designed under his direction were supplied with push button control only for maintaining feedwater temperature.

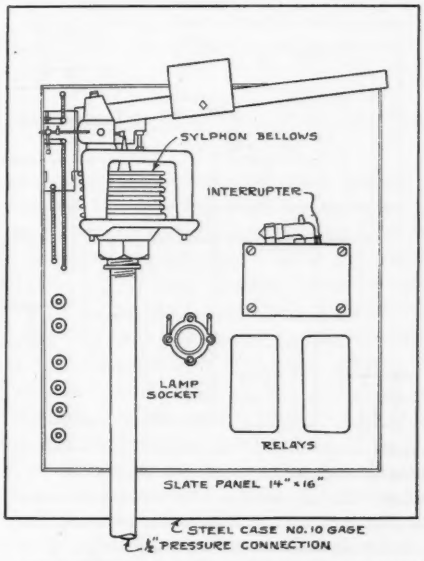


FIG. 1. ARRANGEMENT OF APPARATUS ON THE PANEL

In the design of this equipment, the basic idea was to provide means for controlling a supply of steam at a point remote from the heater to maintain an approximately constant pressure in the heater. Since the steam is supplied to the heater body through a jet heater head, which is practically a jet condenser, the temperature of the water is very close to the saturation temperature corresponding to the steam pressure maintained in the heater. If the pressure is held slightly above atmospheric, the temperature is maintained at 212 deg. F., or higher, so that effective deaeration can be procured through the use of a small heat exchanger, for condensing the steam and cooling the air drawn off, and a vacuum pump.

As shown in Figs. 1 and 2, the apparatus consists of a sylphon type bellows with upper and lower contactors; two enclosed relay switches; an enclosed mercury contactor, opened and closed intermittently by an electri-

*Engineer, W. S. Barstow & Co., Reading, Pa.

cally driven clock and a reversible motor operating the steam throttle on an auxiliary turbine.

The bellows are connected by half-inch pipe to the shell of the heater and the pressure setting of the device is attained by fixing the position of a weight on a lever. The position of the upper and lower contactors, attached to the frame of the bellows, determines the pressure at which the steam valve on the turbine begins to open or close, as the contactors close a low voltage circuit through one or the other of the relays. When the upper contactor on the bellows closes, the relay switch is thrown to make contact in the motor circuit to drive the motor in the proper direction to close the throttle. When the lower contactor on the bellows closes, the relay switch is thrown to close the motor circuit, giving

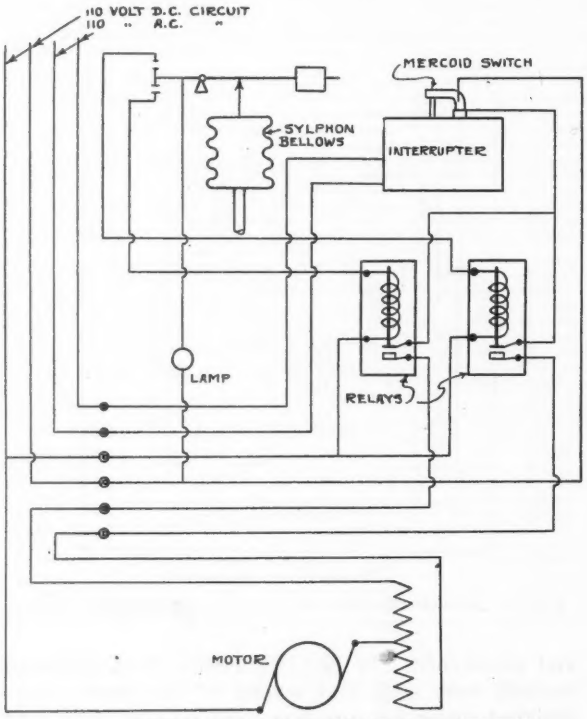


FIG. 2. SCHEMATIC DIAGRAM OF THE SYSTEM

the motor the opposite rotation and opening the throttle. In the line common to both the opening and closing circuits of the motor, however, an intermittent contactor is placed, which closes the circuit for short periods at regular intervals. This contactor is operated by a 60-cycle alternating current motor similar to that employed in electrical clocks and the period of contact can be adjusted to suit the needs of operation.

Four volts are used in the relay circuit so that the loosely held platinum bellows contactors make and break a circuit carrying little energy, therefore they should give no trouble. The fact that the contactors are only loosely held allows them to have a slight rubbing action that tends to clean off any dust which might accumulate on them. The operating circuit has 110-v. direct current, but since the motor on the throttle valve is of fractional horsepower, the relay switches make and break a circuit carrying a fraction of a kilowatt. The mercoid switch makes and breaks the same circuit and will be called on to do this much more often than the relays, since the only time they make or break circuit is when the mercury switch is in contact position, which is only a small percentage of the time.

This entire control is mounted on a small panel and enclosed in a dust-tight iron case suited for attachment to a wall close to the open heater which is generally located in the boiler room.

Several months' operation with two of these controllers has demonstrated that feedwater temperature can be maintained within 2 or 3 deg. F. without any adjustment after the original setting, and this experience has been gained at isolated plants in which the load changes through the day and night, varying between the peak and a minimum of about one-fourth of the peak during the early morning hours.

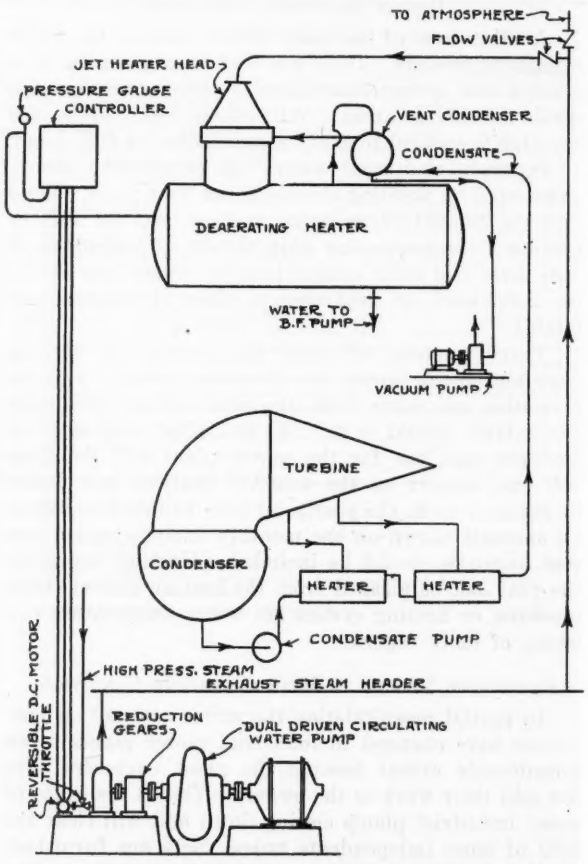


FIG. 3. DIAGRAM OF ENTIRE SYSTEM SHOWING APPLICATION OF TEMPERATURE CONTROL SYSTEM

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DETAILED STUDY of several modern station energy balances shows that the two principal influences on station economy, outside of pressure, are the completeness and condition of its equipment and the efficiency with which variable station loads are carried.

Ability of the boiler room equipment to attain a low stack temperature and high stack $CO_2$ coupled with low turbine room overall heat consumption and an economical auxiliary layout supply the first requirements. Freedom from large standby or starting losses and economical operation under low load fulfill the second.

# Knowledge of Bearing Temperatures Aids Efficient Lubrication

*By H. L. Kauffman*

H. L. KAUFFMAN has been employed as chemist, development engineer, research chemist and investigator by The Texas Co., Pierce Petroleum Corp. and Producers and Refiners Corp. Since 1926 he has conducted private practice as a petroleum consultant in Denver, Colo., specializing in problems of manufacture and utilization of petroleum products. He is an associate member of American Society of Mechanical Engineers and member of American Petroleum Institute, American Institute of Mining and Metallurgical Engineers and other technical societies.

IN POWER PLANTS it is not uncommon to find turbine or other bearings unusually warm and yet causing no anxiety to the engineer in charge. He knows these bearings will not heat to any higher temperatures. These conditions, however, are not evidence of efficient lubrication. This is because excessive frictional heat in a bearing is an indication of loss of power due to an excessive frictional load, the power absorbed by friction having been transformed into heat. High running temperatures in such bearings may be attributed largely to the viscosity characteristics of the lubricating oil in use. The viscosity of the oil is too high to give satisfactory results when the bearings are developing normal running heats. As a result, the bearing is required to develop sufficient heat to reduce the viscosity of the oil to a working value. This, then, allows the oil to flow freely into the bearings. With better circulation, the oil is able to balance the production of frictional heat by carrying it away as fast as it is created.

### Viscosity and Working Temperatures Must Be Considered Together

From the above, the importance of considering the viscosity value of an oil (in this country viscosity is determined ordinarily on the Saybolt Universal viscosimeter) in selecting the proper grade of turbine lubricant is at once self-evident; however, viscosity values should be used more as an indirect than a direct guide in the selection of the proper oil. The method of selecting an oil from its viscosity characteristics should be based upon the temperature at which the oil will be expected to work. In the case of a bearing, this temperature will be the normal working temperature of the bearing. At this working temperature, the viscosity of the oil should be such as to fulfill the mechanical and lubricating requirements of the bearing.

Here let it be mentioned that the viscosities of all petroleum oils decrease as temperatures are increased. This decrease in viscosity with an increase in temperature varies, being dependent upon the source of crude from which the lubricating oil was made. Paraffin base oils, such as those found in Pennsylvania, are less affected by heat than mixed-base oils, such as most of the Mid-Continent oils; and mixed-base oils, in turn, less than asphalt-base oils, such as those found in Southern Texas and Louisiana and most California oils.

Now if we plot the viscosity-temperature curve of an oil, the selection of the most efficient grade of oil for the particular purpose of lubrication will be much simplified. By so doing, comparisons with other oils can be made quickly. An example of the practical use of this method follows.

### Temperature Rise Is a Measure of the Friction Energy

Let us assume that a bearing has a normal running temperature of 110 deg. F., when the room temperature is 80 deg. F. In this case, certainly no heat will pass from the air into the bearing. With the exception of the small amount of heat carried away by the frame, the 30 deg. F. excess temperature is a relative measure of the frictional heat developed in the bearing. This frictional heat is a measure of wasted energy.

On the other hand, if an oil be selected by means of its viscosity-temperature curve, produced from the same crude and having the same viscosity at 80 deg. F. as is possessed by the oil in use at 110 deg. F., the friction in the bearing will be reduced. This is because there will be no need for the viscosity of the second oil to be reduced to a point that meets the mechanical requirements of the bearing.

Data in the table are given to show the influence of viscosity on bearing temperatures, that is, to show how bearing temperatures are increased by the use of improperly selected oil.

INFLUENCE OF VISCOSITY ON BEARING TEMPERATURES

| Time | Room Temp. in deg. F. | Bearing Temp. in deg. F. | Temp. Rise in deg. F. |
|---|---|---|---|
| 10:45 A.M.... | 65 | 122 | 57 |
| 11:00 A.M.... | 66 | 123 | 57 |
| 11:30 A.M.... | 67 | 123 | 56 |
| 12:00 N. .... | Change made to an oil of lower viscosity. | | |
| 2:00 P.M.... | 68 | 101 | 33 |
| 2:30 P.M.... | 68 | 99 | 31 |
| 3:00 P.M.... | 67 | 95 | 28 |
| 4:00 P.M.... | 66 | 92 | 26 |
| 5:00 P.M.... | 64 | 90 | 26 |

In this connection, mention should be made of the fact that, with the use of any particular grade of oil and constant mechanical conditions, the rise in temperature of the bearings above the surrounding air should remain very nearly constant.

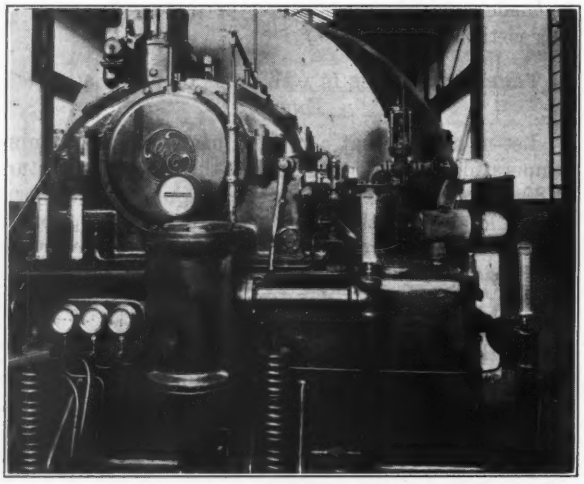
So, too, it should be emphasized that by far the

most efficient practice is to use an oil having the lowest viscosity that will insure the maintenance of the lubricating film in a bearing. Excessive viscosity is as much to be avoided as an insufficient supply of oil.

### Importance of Knowing Bearing Temperatures

Service tests with different oils and a comparison of the increase in bearing temperatures is one means of finding out what grade of oil to use in order to lubricate steam turbines and other power-plant equipment most efficiently. Knowledge of bearing temperatures, however, is of value not only when comparing the relative suitability of two different oils, but is even of greater importance as a guide to the conditions of lubrication, that is, whether or not a proper lubricating oil film is being maintained.

It is seldom that lubrication of bearings on equipment in power plants fails completely. Due to oil



THERMOMETERS ARE GUIDES WHICH SHOW THE EFFICIENCY OF BEARING LUBRICATION

thinning out, however, or because the wrong grade or an insufficient quantity is being used or with dirt and grit in the bearing, it often happens that bearing lubrication is impaired, resulting in increased cost of generating power.

Evidence of impaired lubrication is shown by an increase in bearing friction which is indicated by an increase in the amount of heat in the bearing. Since more friction means more heat, it is possible to measure relatively the amount of friction by measuring the frictional heat of the bearing itself. This is accomplished by noting the temperature of the room in which the machine is located and that of the bearing when it is in service and then finding the difference.

Temperature comparisons as mentioned above are of value in checking lubricating conditions. This test is simple to make, but *the dependability of the results in interpreting the conditions of lubrication is contingent upon the care with which the test is conducted.*

### How to Make a Bearing-Temperature Test

Two thermometers are required for making a bearing-temperature test: one to obtain the temperature of the bearing, the other, to determine the temperature of the room or air.

Room temperature is found by placing a thermometer at some convenient point in the room where it will not be in a direct draught. It should be located so that it will register the air temperature surrounding the bearing, but it must not be placed where it will be unduly influenced by the direct radiation from that bearing or other bearings in the machine. In many plants where bearing temperatures are determined regularly, the room temperature is taken from the dry thermometer of a hygrometer, an instrument used for determining the relative humidity.

When it is possible to do so, the thermometer employed for getting the bearing temperature should be placed in the oil. However, the temperature of the bearing can also be learned by putting the thermometer at any point on top of the bearing where it will be safe and where the bulb of the thermometer will be close to the greatest possible amount of bearing metal.

### Precautions to Take in Using Thermometers

To reduce to a minimum the possibility of breaking the thermometer, it should be tied in place. It is also advisable, in fact, for accurate results, necessary, to protect the thermometer bulb by asbestos in order to reduce the influence of air. This asbestos can be so formed as to fit about the bulb without touching it, and can be held in place by the same string used for tying fast the thermometer.

When tests are to be made over an extended period of time and where thermometers have to be removed and replaced, it is prudent either to label the thermometer or to make a record of its number and the exact place where it is to be used. By following this practice, instruments always will be on the same stations for the series of tests. Since any slight differences will always be equal so long as the same thermometers are used for the same observations it is less important to have the thermometer absolutely standard.

For recording data obtained in making a test, it is well to prepare in advance a sheet with the following four column headings: time, room or air temperature, bearing temperature, frictional temperature, which is the difference between bearing temperature and room temperature. Naturally if machine speeds, which also are a relative indication of the amount of friction, are to be taken, more columns should be provided. If many different shafts or spindles are to be tested, however, it is advisable to prepare a separate log sheet for recording speeds. By so doing, the record of frictional conditions can be kept in two parts for ready reference. For accurate results, all determinations of bearing temperatures should be made in duplicate.

### How to Test Different Oils by Comparing Bearing Temperatures

Relative quality or suitability of two different oils for the lubrication of the bearings of a particular machine can be ascertained by comparing the bearing temperatures when the machines using those oils are in operation. It is absolutely essential that both the bearing and the machine be in exactly the same physical condition for both tests; otherwise, some other condition, such as, cleaning the machine or adjustments of some of the movable parts rather than the state of

lubrication, may be the cause of the particular test-results obtained.

When two oils are to be compared by making a bearing-temperature test, clean the bearings carefully before each test in exactly the same manner. Such cleaning must be accomplished without dismantling the bearings and related parts of the machine, for, if this were done, the adjustment would be interfered with.

Cleaning the bearings requires careful consideration. Sometimes flushing with kerosene thoroughly cleans the bearings; in other cases, flushing with a light-bodied mineral oil will give more satisfactory results. Whatever means are utilized, make sure that all traces of flushing oil are removed before placing the trial oils in the bearings. It is possible to make certain that all oil employed for cleaning has been removed by actually flushing out the bearing again with a small amount of the particular oil undergoing test.

### Test Over a Period of Time Advisable

If considerable difficulties are encountered in cleaning the bearings, it is good practice in comparing two oils to clean the bearing, use one of the oils to be tested for a week or two and *then* make the bearing-temperature test. Having completed the test, remove the first oil, flush out the bearing and put the second oil into use for *exactly the same period of time as the first* before making the test. By following this procedure, you can be reasonably certain that lubrication with both oils has been carried out under approximately the same conditions of cleanliness—all of which means that the test results obtained are that much more dependable.

In addition to the value of measurement of bearing temperatures as an indication of the suitability of two or more different oils, it should be emphasized that such tests are an excellent guide to the condition of lubrication being obtained in regular plant operation.

Specialists on problems of power-plant lubrication, acting as consultants, are receiving as high as $50.00 a day for running bearing-temperature tests. There is no reason, however, why any person of average intelligence, following the fundamental precautions outlined in this article, can not determine bearing temperatures as satisfactorily as a lubricating expert and by so doing, that person will have at hand a constant guide to the efficiency of lubrication of his particular equipment.

# Trend of British Steam Station Practice

Standardization of Equipment, Plant Capacity and Practice Advocated as a Step Toward Reducing Losses Due to Development Costs. By H. L. Guy*

OF TENDENCIES affecting the thermal efficiency of steam plants, perhaps the most evident is the pronounced movement toward higher steam pressures. The motive lies in the thermal advantages offered, which are set out in Table I, based upon 700 deg. F. total temperature, 29 in. vacuum, four stages of feed heating and including boiler and condenser auxiliaries. The table is also applicable for a total temperature of 900 deg. F. if the gain for 100 lb. per sq. in. above 700 lb. absolute is increased by 0.17 per cent. With a 28-in. vacuum the gain is increased by 0.25 per cent per 100 lb. per sq. in. increase in pressure. The law of diminishing returns holds in a marked manner.

On theoretical grounds, reheating to the initial temperature might be expected to increase the gain by 0.125 per cent per 100 lb. per sq. in. increase in pressure. Experience raises doubts, however, whether this increased gain will materialize.

There should be little well founded objection to the standardization of such series of initial pressures as those given in Table I. Surely there can be no real justification for calling for such a variety of pressures as 300, 325, 350, 375 and 400 lb. per sq. in. when the maximum difference of thermal efficiency of the extremes from 350 lb. per sq. in. is but 1¼ per cent.

### 20,000-Kw. Units Set as Minimum Size for 550-Lb. Pressure

Apparently the great importance of size is not generally appreciated. It is doubtful whether at present 350 lb. per sq. in. should be adopted for condensing plants having a lower maximum continuous rating than 10,000 kw. or 550 lb. per sq. in. for less than 20,000 kw. These are the probable minimum desirable ratings for the pressures stated and not necessarily the desirable pressures for these ratings.

*From paper presented before the Institution of Civil Engineers.

TABLE I. INCREASE IN STEAM PRESSURE CORRESPONDING TO 3 PER CENT STEPS IN THERMAL EFFICIENCY. BASED ON 700 DEG. F. TOTAL TEMPERATURE, 29 IN. VACUUM AND FOUR STAGES OF FEED HEATING

| Increase in Thermal Efficiency: per cent. | 3 | 6 | 9 | 12 | 15 |
|---|---|---|---|---|---|
| Initial Pressure: lbs. per sq. inch. | Final Pressure: lbs. per square inch. | | | | |
| From 200 to | 265 | 365 | 505 | 764 | 1,360 |
| „ 250 „ | 342 | 472 | 703 | 1,200 | |
| „ 350 „ | 495 | 755 | 1,390 | | |
| „ 500 „ | 785 | 1,530 | | | |
| „ 750 „ | 1,470 | | | | |
| „ 1,400 „ | — | | | | |
| Reduction in Coal-Consumption: per cent. | 2·92 | 5·66 | 8·26 | 10·71 | 13·04 |

Installing high-pressure boilers where a considerably lower pressure is already established is attracting attention. This high-pressure steam is preferably expanded in a separate back-pressure unit and returned to the new boilers for reheating to something like the initial temperature before admission to the older steam mains. With an initial and reheating steam temperature of 750 deg. F., at the higher steam pressure of 1200 lb. per sq. in., the back-pressure unit will generate 3450 kw. for each 10,000 kw. generated by the low-pressure plant

working at 250 lb. per sq. in., or 2350 kw. at the low pressure of 350 lb. per sq. in.

Increase in generating capacity is obtained with an increased total coal consumption. If the lower-pressure plant is not reasonably efficient the more economic course would be either to reserve it for peak loads or to scrap it and install a new plant at an intermediate pressure. Increase of cost with pressure has, in this country, decreased about 15 per cent on the average in 2 yr., thus leaving the desirable pressure selection dominated by economic issues.

Reheating by transfer of heat from steam to steam is attracting attention. If, for example, steam is supplied to a turbine at 525 lb. per sq. in., 750 deg. F., and if 10.25 per cent is condensed in a steam reheater, the final wetness will be reduced to about 6 per cent, with a maximum thermal gain of about 1.9 per cent.

### Advantage of Flue Gas Reheats at Lower Pressures Doubtful

If steam is generated at 850 deg. F. and this additional 100 deg. F. is transferred in a reheater following that just postulated, the maximum thermal gain would be raised to 3.3 per cent and the wetness at exhaust reduced to 3.5 per cent. The thermal gain would be slightly greater with no reheat, but with steam supplied at 850 deg. F. Such a reheating system would be employed, therefore, only under the doubtful assumption that higher temperature steam can be successfully generated and transmitted than steam turbines can be successfully constructed to employ.

TABLE II. INCREASE IN TOTAL TEMPERATURE CORRESPONDING TO 3 PER CENT STEPS IN THERMAL EFFICIENCY. BASED ON 700 DEG. F. TOTAL TEMPERATURE, 29 IN. VACUUM AND FOUR STAGES OF FEED HEATING

| Increase in Thermal Efficiency: per cent. | 3 | 6 | 9 | 12 |
|---|---|---|---|---|
| Initial Pressure: lbs. per sq. inch. | Increase in Temperature: °F. | | | |
| 200 | 72 | 143 | 215 | 290 |
| 250 | 73 | 146 | 219 | 292 |
| 350 | 74 | 148 | 222 | |
| 500 | 75 | 150 | | |
| 750 | 73 | | | |
| 1,400 | 63 | | | |
| Reduction in Coal-Consumption, per cent. | 2·92 | 5·66 | 8·26 | 10·71 |

In the past, reheating has been adopted as a drying agent and the bulk of experience gained is based on conditions which limited the final wetness to 10 per cent. In spite of this and the 5 to 6 per cent thermal improvement obtainable, there is now a decided tendency against reheating by flue gases, at least for pressures below 800 lb. per sq. in. as the additional apparatus is large and costly. Between 1000 and 1500 lb. per sq. in., the disadvantages of flue gas reheating are minimized and the desirability is increased. The present tendency is to retain flue gas heating in such stations.

Both the advantage and need of reheating practically appear as it becomes possible to work at considerably higher temperatures. Thus if 810 deg. F. and 950 deg. F. could be used with initial pressures of 600 and 1000 lb. per sq. in. respectively, the wetness factor at exhaust will be the same as with 350 lb. per sq. in. 700 deg. F.

### Thermal Efficiency Can Be Increased Either by Higher Pressures or Temperatures

Temperature increases which increase the thermal efficiency by steps of 3 per cent are given in Table II. Comparison with Table I shows that an increase of 408 lb. per sq. in. from 350 to 758 lb. per sq. in. gives the same thermal gain as an increase in total temperature of 145 deg. from 700 to 845 deg. F.

Regenerative steam heating has become firmly established in this country where it was initiated. Temperatures at the outlets of feed heaters are being generally raised, consequently the number of stages is increasing. This is resulting in the addition of air heaters and the retention of the economizer. In some other countries, where elaborations were practiced never entertained here, the tendency is toward simplification.

Feed heaters tend to become fewer, oil and air coolers are being removed from feed heating service and economizers are showing signs of being introduced in conjunction with air heaters. There is a decided tendency to eliminate chemical water treatment and to substitute evaporators coupled either in parallel with one stage of feed heating or taking the place of one stage.

### Standards of Test Conditions Needed

Introduction of feed heaters, evaporators and ejectors introduces a dilemma in the contract definition of performance and tests, but this is being overcome as experience is gained. It is, however, desirable to give guarantees and take contract tests with the evaporator cut out or bypassed. For like causes, there is a tendency to seek new methods of stating performance.

Possible systems are for given steam conditions, vacuum and steam temperatures, by A, steam consumption; B, heat consumption; and C, thermal efficiency. The first is, perhaps, the simplest, because it is the first quantity deducted from the test and gives the figure of merit, whereas that deducted for B or C would depend upon the steam tables used, while C also depends upon the value adopted for fuels equivalent.

On the other hand, B and C are more readily translated into coal consumption and have the added advantage that, with given variations of steam pressure, temperature and feed temperature, any necessary test corrections are considerably reduced. It is very desirable to reach agreement on the exclusive use of one of these systems.

Unfortunately there is little tendency toward standardization of the capacity of plants. With interconnection of systems and centralization of control, the necessity for a multitudinous diversity in capacity must surely disappear. The cost of developing a particular size of unit is considerable and definite multiplication of such changes represents a serious loss.

Great advantages would accrue if one of the following ratings could be standardized for 2 yr.: 1. For intermediate stations, 20,000, 25,000, 30,000 kw. at 3000

r.p.m.; and 2, for larger stations 50,000 or 60,000 kw. at 1500 r.p.m.

The same would apply if standardization could also be effected for like period in the matter of steam temperature and pressure. In order to encourage and promote development, a certain proportion of this construction might, and should be, deliberately experimental. Under such a plan, stimulated by the meritorious example of the purchaser, manufacturers might be induced to pool their resources in order to undertake such experimental plants as a joint effort for the national advantage.

# Store Keeping at Acme Station Aids Service

SYSTEMATIC KEEPING OF SPARE PARTS, TOOLS AND ACCESSORIES IS AN ESSENTIAL TO CONTINUOUS SERVICE. BY ALAN A. WOODWARD*

TIMES occasionally come in the emergency repair of power plant equipment when minutes mean dollars. After having been called out after midnight, perhaps, on some repair work that has to be completed before the morning load comes on, what is more exasperating and unnecessary than to lose an hour's time hunting for some elusive spare part? The fact that somebody saw this particular piece last week doesn't help one iota in the emergency at hand and the net result to the company is an increased cost of the repair work done in this particular case, a slump in the morale of the maintenance gang and the jeopardizing of the plant's continuity of service. Good housekeeping, therefore, with reference to spare parts, tools and accessories is essential to up-to-date power plant operation.

FIG. 1. GENERAL VIEW OF THE LOWER STORE ROOM IN WHICH IS KEPT THE HEAVY STOCK, SUCH AS STOKER PARTS, REFRACTORIES AND BAGS OF CEMENT

In keeping adequate supplies on hand at all times, a well designed and equipped stores department is a great help, also in keeping this material where it is available for use at any time of the day or night. At the Acme station of The Toledo Edison Co. a system

*Boiler Room Foreman, Acme Station of The Toledo Edison Co., Toledo, O.

of store keeping has been installed which is exceptionally complete and which embraces the entire production department's requirements from soap to main unit bearings.

At this station, the stores department occupies a portion of two floors in the boiler plant, or a total floor space of 10,000 sq. ft. On the lower floor is kept the heavier material such as stoker castings, refractories, clay, lime, turbine bearings and boiler tubes. As will be noted from the illustration, most of this equipment is piled neatly on the floor and in the case of stoker castings, each pile bears the casting number for easy identification. Boiler tubes are kept in a rack specially built for them, and some of the smaller stoker parts are kept in bins. A chain hoist, operating on an overhead rail, covers the length of this room, and aids in the handling of some of the heavier castings.

### Arrangement of Stock in Bins

On the upper floor, the quick moving stock is kept in well organized steel bins, arranged on either side of

FIG. 2. ONE AISLE OF THE UPPER STORE ROOM WHICH HOUSES THE LIGHTER AND FASTER MOVING SUPPLIES

two aisles running the length of the store room. The close up view of the bins gives some idea of their construction and assembly. The size of the individual compartments can be varied to suit the particular type of article to be kept therein. Each bin is plainly marked with a card showing the character of its contents, and in case the parts located in one bin are not all the same, each piece bears an identification tag.

For example, governor parts for a boiler feed pump drive would all be kept in one bin marked, "Governor parts—No. 1 b.f.p. turbine," and to each piece would be attached a specific description (corresponding to a similar nomenclature in the stock ledger) such as, "Governor valve stem—No. 1 b.f.p. turbine," or, "Knife edge blocks—No. 1 b.f.p. turbine," etc. In general, of course, the lighter material is kept in the upper tiers and, since the room is long in comparison to its width, the faster moving supplies are kept as closely as practicable to the disbursing window.

Overall height of the bin structure is 8 ft. This is a desirable feature since all but the top row of compartments can be reached from the floor, thus practically eliminating the necessity for movable ladders.

In order to facilitate the location of supplies when called for, different classes of material occupy certain sections of the bins. All electrical repair parts, for example, are kept in one series of compartments, while pipe fittings occupy another section, valves another and crane repairs another. Small stoker parts and boiler accessories are grouped together, while all auxiliary turbine and pump repairs are segregated in still another section. Space is also provided for paint, packing, gage glasses, lamps, cleansing material, cable, bronze stock, bolts, nuts, washers, and a host of other miscellaneous material used in the operation and maintenance of a plant.

Throughout the construction of the store room, every consideration was given to render it fire proof. The walls, floors and ceilings are of concrete. The bins, shelves and racks are all steel and, since only a small percentage of the material stored is of an inflammable nature, the possibility of damage by fire is small. As a further precaution, however, a good sized chemical fire extinguisher is kept ready for instant use. In accordance with insurance regulations, the lubricating oil stock and gasoline storage are located outside the main building.

### What to Keep in Storage

No matter how well the physical side of the store room may have been designed, its usefulness may be limited if the required amount of thought has not been given to the material it houses. Adequate protection with a minimum investment is the end desired and this cannot be reached by haphazard consideration.

In the case of spare parts for operating equipment, the chief engineer in consultation with his maintenance foremen should decide what supplies are essential and in what quantities they should be carried. The store keeper is advised of the maximum and minimum number of any given part to be kept on hand and a notation to this effect is placed at the head of stock ledger sheet covering this item. Experience will soon indicate whether or not a sufficient number of units is being carried and adjustments can be made to fit the requirements.

Fast moving stock must be watched with care to avoid the possibility of shortage, and material for which there is only occasional use should be ordered with discretion in order to keep the total inventory as low as is permissible without sacrifice of safety. Particular attention must be given to such material as refractories and stoker castings, the demand for which is variable in accordance with changes in operating conditions. The location of the plant with respect to a good source of supply will have a direct bearing on the contents of the store room.

### Clerical System Used in Ordering Stock

It might be well to state here that the store room under consideration is one of several on the Toledo property, all of which are controlled through the purchasing department. The individual store rooms have their own detailed records covering the material put into and taken out of stock. Central records of a broader and less detailed nature are kept at the main

office, but the balance on hand at the end of each month as indicated by the store keeper's records must check with that of the central records.

The clerical process involved in making a purchase that is to be charged into stock is as follows: A memorandum for material to be bought is made out by any one of several foremen, and is okayed by the chief engineer. The store keeper then executes a purchase requisition covering this merchandise and passes it over the desk of the plant superintendent for final approval. The purchasing department then issues the formal order in triplicate—the original going to the vendor, one

FIG. 3. A CLOSE-UP OF THE STEEL BINS, GIVING DETAILS OF THEIR ASSEMBLY, ALSO METHOD OF MARKING STOCK

copy to the store keeper, while the third remains on file. Upon the arrival of the goods, the store keeper checks the shipment against his copy of the order which he returns to the main office, if every item of the order has been received complete. The presence of this copy in the files of the auditing department indicates that the material has arrived and that the bill is payable when presented. A duplicate of the vendor's invoice comes to the store keeper, who posts the items onto his stock ledger sheets and the material itself is properly marked and placed in the bins.

Material may be drawn from stock on a requisition properly authorized. Each requisition must bear the name and quantity of articles being withdrawn, the use to which they are to be put, the account to which they are chargeable, the name of the individual receiving the material and the signature of the foreman responsible for the requisition.

Stock ledger sheets used are of a standard type, being designed to show a perpetual inventory of each item. A brief description of the article heads the sheet, together with a notation of the maximum and minimum quantities to be carried in stock. "Material received," "disbursements" and "balance on hand" are the main column headings, each of which is further subdivided to show the date of entry, quantity, unit price and the total amount in dollars of the transaction. The perpetual inventory is checked twice a year against a complete physical inventory of the contents of the store room.

As stated above, items entered into the "material received" column are taken directly from the vendor's invoice. The stock requisitions furnish the store keeper a ready means of posting disbursements onto the ledger, while, of course, the balance on hand is computed. In compiling equipment maintenance costs, the stock requisitions are again used to show the value in dollars and cents of all material drawn from stock and applied to maintenance. At the end of each month's business, a stock voucher is set up by the store keeper, covering every item of material disbursed. This becomes a part of the central office records, to be used in crediting the different stock accounts and debiting operation and maintenance.

Although the writer has no comparative figures at hand, it would seem that this department works on an economical basis. A store keeper and three assistants comprise the entire personnel of the store room which is operated on a 24 hr. per day schedule. Besides the routine work of handling a yearly stock turnover of more than $100,000 and the clerical work incident to the recording of these transactions, the men also find time to do the minor repairs of the department and are constantly making improvements in the methods of handling stock and in the arrangement of material on hand.

## Progress in Stoker Control

ACCORDING to the stoker and furnace reports of the N. E. L. A., the principal phase in the development of stoker equipment and furnaces in the past year is the application of automatic combustion control. Most new installations contain this feature, while many of the older ones are being provided for full or partial automatic operation as conditions warrant.

Definite data from a number of companies substantiate the utility and value of this equipment, while the manufacturers, cognizant of the demand for improved equipment, have contributed considerable data on their latest developments along this line.

Stoker capacities are increasing to meet the demand for increased heat liberation. In the design of the newer stoker models, much attention is given to the regulation of air to various parts of the fuel bed and interesting test data on the air requirements for various combustion rates are included.

Preheated air and longer stokers have made water walls increasingly necessary and few installations are now made without some form of water-cooled surface. Considerable data and a number of heat transfer curves on cooled and uncooled walls are included. Among these are given temperature gradients through bare cast-iron blocks and refractory faced cast-iron blocks.

# Evaluating Proposals for Power Equipment

DESCRIPTION OF THE PROCEDURE OF THE BROOKLYN EDISON CO. IN PURCHASING EQUIPMENT AND COMPARING PROPOSALS. BY L. D. BONNETT*

IN EXTENDING power plants or building new ones, engineers strive to obtain the best possible results, taking into account both first cost and operating cost. After the general plan of design has been decided upon, perhaps the most important factor bearing on final results is the selection of the individual pieces of equipment that, together, make up the power plant.

It is the belief of our company that prudent selections can best be reached when there is the freest and wide open competition among manufacturers. When purchasing and engineering functions are separated, as they now are in most large companies, satisfactory results of such a policy are possible only through coöperation, confidence and understanding between the purchasing and engineering departments.

Our process for purchasing competitively interweaves through the two departments and may, perhaps, be divided into four parts: 1. The specifications prepared by the engineers. 2. The obtaining of proposals under these specifications by the purchasing department. 3. The evaluation of these proposals through the coöperation of both departments. 4. The final closing of the purchase.

## SPECIFICATIONS

Specifications are intended primarily to describe the operating results to be obtained. These are just as wide open as possible, leaving to the judgment of the bidder the detailed methods by which the result is accomplished. The specifications must, of course, define limiting conditions, such as available space, maximum size and weight of the parts, temperatures which can be handled, pressures and other miscellaneous data.

Such specifications, we believe, allow the widest latitude to all manufacturers to present the proposition to best suit their particular methods of manufacture and design and thus give us the broadest view of possible variations from which we can choose.

These specifications are then submitted by the purchasing department to manufacturers for proposals with the request that the proposal be separated into two parts; first, the complete engineering proposal, including all performance guarantees and the second part telling the price and date of shipment.

## EVALUATION OF PROPOSALS

It must be recognized that the selection of material to be purchased is a matter of judgment and cannot be a matter of rigorous mathematical solution. It has been our experience that if we form first our judgment of the relative advantages of different propositions and engineering data only, without price, we can with more freedom from prejudice weigh the advantages and disadvantages other than those expressed in actual performance guarantees.

We believe it to be a sound policy in comparing propositions to take the performance guarantees of the manufacturers at their face value without any corrections for probable or possible different margins of safety which may be claimed. If a manufacturer desires to make a certain guarantee and then asserts that he has an extra large factor of safety, we are compelled to believe either that the factor of safety is mostly the salesman's talk or that the company submitting the proposal has not the courage of its convictions.

We expect to make tests after installation for all equipment to see that it meets its guarantees, thus we expect the manufacturer to retain a sufficient margin to cover the contingency that his experience indicates is necessary.

## OBVIOUS MISTAKES ARE SENT BACK FOR CORRECTION

Occasionally guarantees come in which are so far out of line with usual performance, sometimes better, sometimes worse, that apparently some error in calculation has been made. Such apparent errors or inconsistencies are, of course, called to the manufacturer's attention for correction or justification. An estimated load duration curve on the main unit is the basis of mathematical evaluation of performance guarantees. Despite the admitted inaccuracy of such load curves, it is unquestionably more accurate than just an off-hand guess of the average useful life of the machine.

Because of the inexactness of the premise, extreme accuracy in arriving at the annual capitalized operating cost is not necessary. It frequently happens that the obviously most efficient and most suitable machine is also the lowest in first cost and the choice can be settled without question. In other cases, it is necessary that a complete analysis be made to indicate the capitalized advantage of one proposition over another.

Then there are factors on which only rough estimates can be made. For instance, one piece of equipment may occupy much more space than another. Because of that, changes in construction charges on other parts of the job would have to be increased or decreased to meet it. Duplicate equipment may reduce the value of spare parts necessarily held in stock. Dissatisfaction with performance in the past is, of course, sound reason to reject the proposal unless evidence is presented that difficulties have been overcome.

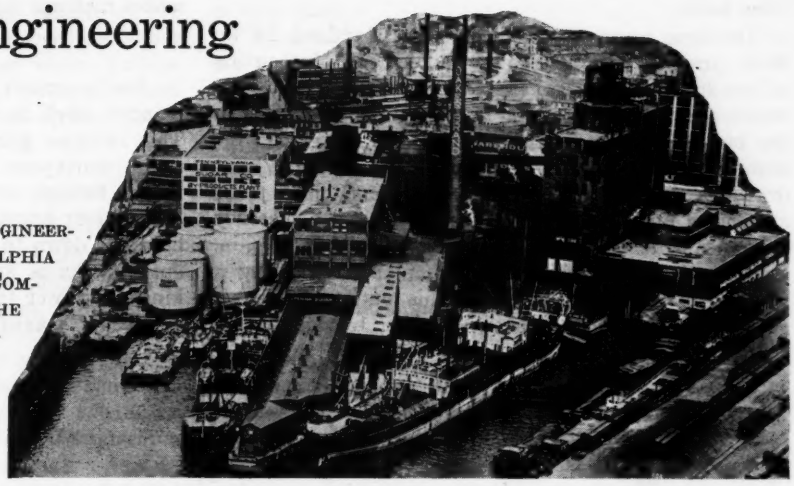
When the performance calculations have been completed, the results are gone over and discussed between those responsible for operation, engineering and purchasing and the final figures agreed upon showing the comparative values to the company of the different propositions under consideration.

Considering also matters of purchasing policy, dependability, time required for manufacturing, reputation of the manufacturer for fairness in taking care of minor changes and the encouragement of competition, we feel that this procedure has a definite effect in encouraging the manufacturers to propose the best equipment that they know how to make.

*Purchasing Agent, Brooklyn Edison Co. From a paper presented before the Metropolitan Section of A. S. M. E.

# Duties of the Engineering Organization

*By*
*Dan Gutleben* *



MULTITUDINOUS ACTIVITIES OF THE ENGINEERING DEPARTMENT IN THE PHILADELPHIA PLANT OF THE PENNSYLVANIA SUGAR COMPANY REFLECT THE IMPORTANCE OF THE ENGINEERS' WORK IN A LARGE INDUSTRIAL PLANT. METHODS IN USE HERE SHOULD BE EQUALLY APPLICABLE IN OTHER INDUSTRIES HAVING SIMILAR PROBLEMS OF REPAIR AND MAINTENANCE WORK

WITH A DAILY capacity of 3½ to 4 million lb. of refined sugar, 20,000 gal. of alcohol and 5 to 7 t. of liquid $CO_2$, the plant of the Pennsylvania Sugar Co. at Philadelphia, Pa., requires for its proper operation and maintenance, an engineering staff capable of dealing with problems of varied character with skill and resourcefulness.

Continuity of operation is essential in a plant of this kind. In this plant, the by-products division operates continuously but the sugar refinery closes down on Sundays, during which time the Engineering Department proceeds with the overhauling and improvements.

PERSONNEL OF REPAIR AND MAINTENANCE CREW

| | |
|---|---|
| Master mechanic | Machinist foreman |
| House mechanic | Machinists |
| Millwrights | Blacksmiths |
| Oilers | Welders |
| Pump repairmen | Sheet metal foreman |
| Belt repairmen | Head pipe fitter |
| Centrifugal repairmen | Yard foreman in charge of coal handling cranes |
| Riggers, boiler makers | Store keepers, tools, stores and repair parts |
| Boiler house operators | Carpenter foreman |
| Engine room operators | Carpenters |
| Night mechanic | Concrete men and laborers |
| Bricklayer | Garage foreman (trucks) |
| Chief electrician | |
| Painter | |

All design, construction and maintenance of the plant comes under the cognizance of the Engineering Department and, on account of the great number of processes, it requires versatility in its men and a considerable variety of tools. Continuity of operation is especially important because sugar is not chemically stable until it has been packaged. To assure this continuity of operation the maintenance crew has developed specialty men whose business it is to look after certain equipment such as centrifugals, power transmission, pumps, engines, etc. Each of these men has one or more helpers and is ordinarily kept busy at his specialty but when their work is slack or when an emergency arises elsewhere, they are available for any kind of work and especially in the revision and improvement of equipment to anticipate obsolescence.

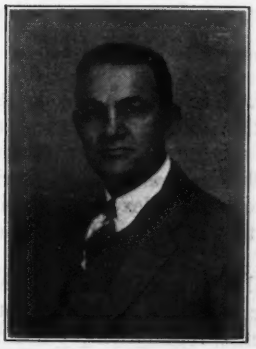
*Chief Engineer, Pennsylvania Sugar Co., Philadelphia, Pa.

### ORGANIZATION OF ENGINEERING DEPARTMENT

Under the office of the Engineering Department, which comprises a drafting room directed by the engineer and including draftsmen and clerks, is a crew aggregating 164 men as shown in the table.

Call for repairs as well as suggestions for improvements are all *cleared* through the engineer's office. Orders go to foremen by means of 3¾ by 6¾-in. cross sectioned memorandum sheets.

These sheets fit standard I. P. loose leaf covers one of which is carried by each foreman. Incidentally, a most convenient device for filling these sheets is a dicta-



DAN GUTLEBEN, after his graduation at the University of Nebraska in 1900, joined the Oxnard Construction Co. on beet sugar plants in Michigan, later continuing the same kind of work with the Dyer Co. of Cleveland. In 1907 he moved to San Francisco and with Gutleben Bros., contractors, built buildings and bridges, government radio stations in Alaska and several beet sugar factories in Utah and Idaho. In 1921 he joined the Pennsylvania Sugar Co. as engineer, designing buildings and building a cane sugar mill in Miami, Florida, and a by-products plant in Philadelphia. He is now in charge of the engineering department of this company in Philadelphia.

Typical of the ingenuity displayed by Mr. Gutleben in handling the varied problems of this plant is the complete plant elevation drawing 40 ft. long, as described in his article.

phone which does most of its work outside of the clerk's office hours.

Drafting room files contain 3000 standard 24 by 36-in. tracings and an equal number of blue prints of machinery such as engines, pumps, boilers, etc., which are not designed by the staff. All columns in the buildings have painted on them on each floor the number that appears on the original and all subsequent drawings. Prints of $\frac{1}{10}$-in. scale ground floor plans are posted up in various places for reference. The key reference drawing is a general outline which is a $\frac{1}{8}$-in. scale vertical development of the plant resembling a railroad profile. A section of this outline, which is some 40 ft. in length, is shown in Fig. 1, which represents the filter press station. The outline is sometimes developed coincident with the design and serves as a convenient tool for the field erector as well as the operators. This device furnishes a method of storing technical statistics with automatic index and describes the equipment in a manner that is not possible in Noah Webster's language.

Like any other chemical plant, a refinery is continually changing and the drafting room prepares drawings for special machines, foundations, buildings, conveyors, elevators, piping, etc.

As column loads change with rearrangement of equipment, the column schedule is revised. The basement columns are marked with a centerpunch to allow checking against settlement. The drafting room also makes material lists for new jobs.

## Standardization

An important part of the drafting room's maintenance work is to standardize on mechanical units. This includes gears, sprockets, chains, gear reductions units, conveyors, elevators, pumps, motors, bearings, valves, fittings, etc. A few years ago there were about 30 different gears for important drives which have now been cut down to four kinds. When some of the present old chains are worn out there will be only four kinds of power transmission chains, viz.: 1 in., 1½ in. and 2 in. manufacturers standard steel roller chains and $\frac{0}{10}$ pitch Morse silent chains, a considerable number of which are used.

About six years ago a new standard of centrifugal pumps was established and sizes 2 in., 3 in., 4 in., 5 in., 6 in. and 10 in. were selected. The 5-in. size will be discontinued. All of these pumps have large casings so that in the 4-in. pump for example, the impeller diameter may vary from 11 in. to 18 in. With the d.c. motors used in the plant, this allows wide flexibility. Considering that the demand for exhaust steam for process exceeds that produced from the engines, power economy in the pumps is secondary to reliability and it was assumed that the large diameter, comparatively slow moving single stage impellers (usually not over

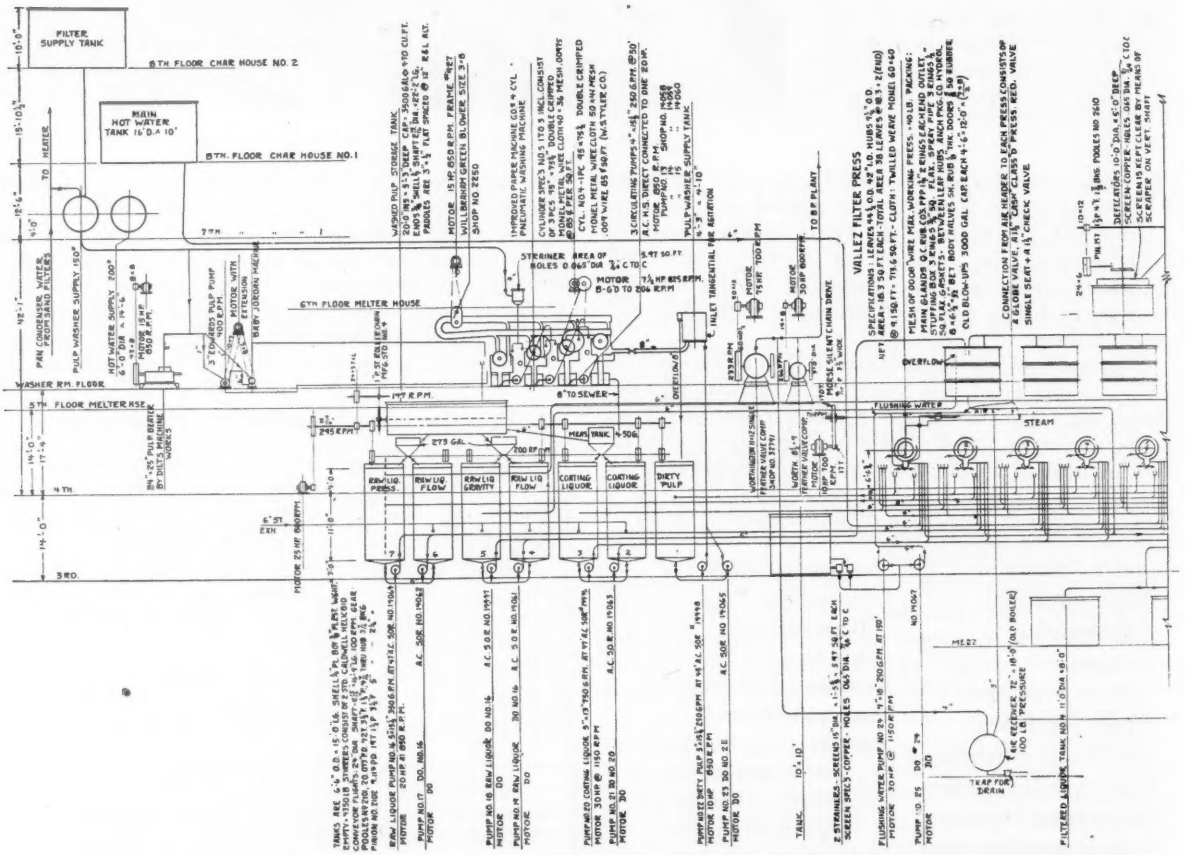



FIG. 1. PORTION OF GENERAL KEY REFERENCE DRAWING

The actual blue print of which this is a part is a ⅛ in. scale vertical development of the plant and is about 40 ft. long. All equipment is described fully and its location with reference to other equipment shown.

1150 r.p.m.) would stand up longer than high speed.

When conveyors, elevators or special machinery are required, the drafting room details the steel and other parts, orders the standard ball bearing idlers, pulleys and gears on a merchandise basis, the structural steel from a fabricating shop and all of the special parts, sheet metal, etc., from the refinery shops.

### Machine Shop

Machine shop tools include one 54-in. by 20-ft. engine lathe and four smaller ones, a W. & S. turret lathe, a No. 2-B Milwaukee miller, a grinder, shaper, planer, internal keyseater, 150-t. hydraulic press, radial drill, two post drills, power hack saw, shear, bolt machine and a large number of accessories, such as acetylene outfits and a portable electric welder. The machine shop also has a skillful blacksmith with a small power hammer and other tools. The primary function of the machine shop is to make repairs but when it is built up so as to be able to take care of emergencies with the required promptness, it would have much idle time on its hands.

with special wear-resisting metal. Pipe railing can be quickly made.

When making repairs in a hot furnace or tank, we use a tool borrowed from the mining industry that makes working conditions more comfortable. This equipment consists of a portable blower with a 12-in. canvas Flexipipe hose. The blower is located at the window nearest the work and delivers fresh air to the men working in the heat.

### Sheet Metal and Carpenter Shops

In the sheet metal shop there is a 10-ft. steel break, rolls, shears and sundry small tools. A small electric "Unishear" hand shear is used for cutting light steel up to No. 18 B.w.g. It can cut all kinds of shapes like a scroll-saw and do it rapidly and without fatigue to the operator. This shop has recently built new elevator casings, hopper-bottom bins for storing three million pounds of sugar, dust collectors, ventilating systems, spiral chutes, machinery guards and everything that is needed of sheet metal or copper.

SCHEDULE OF PUMPS & MOTORS

| № | DUTY | | LIQUID | | HEAD | | PUMP DATA | | | | | | | | | | MOTOR DATA | | | | | | PRICES | | REMARKS | № |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 101 | MOLASSES CELLAR | MAT'L | 100 | 125 | 25 | 25 | 50 | KINNEY ROTARY | 5D696 | 61756 | 4 | 4 | 4" | SIDE DIS | 325 | 66 | 12 | | | | C.W. | 2520 | 25J | 15 | 510363 | 850 | 760 | 529.40 | GEARING | 1 |
| 102 | " " | " | " | " | " | " | " | BRONZE FITTED | " | 61771 | " | " | " | " | " | " | " | | | | " | " | " | " | 512073 | " | 760 | " | " | SAME AS NO. 1 | 2 |
| 103 | " MIXER | " | " | 30 | 82 | 18 | 100 | KINNEY ROTARY | 5D333 | 52329 | 3 | 3 | 3" | " | 285 | 48 | " | | | | " | 2700 | ESJM | 10 | 512061 | 1800/1000 | 925 | 441.40 | " | 3 |
| 104 | " " | " | " | " | " | " | " | BRONZE THROUT | " | 52328 | " | " | " | " | " | " | " | | | | " | " | " | " | 512059 | " | 925 | " | " | SAME AS NO. 3 | 4 |
| 105 | ALCOHOL TRANSFER | " | | | | | | ALLIS CHALMER | H.S. | 12451 | 4" | 3 | 16½ | CLOSED | 1100 | 52 | 1½ | 2½ | 2½ | 1250 | | 2520 | 25J | 15 | 512079 | 1100 | 760 | 475.00 | C.I. BASE SPARE IMPELLER—MOTOR PRICE DOES NOT | 5 |
| 106 | " " | " | " | " | " | " | " | " | " | 12452 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | 512081 | " | " | " | " | INCLUDE STARTERS | 6 |
| 107 | " " | " | | | | | | " | " | 12453 | 3" | 2½ | 16 | " | 1250 | 96 | " | " | " | 1100 | " | 1970 | 15J | 10 | 512077 | 1250 | 572 | 500.00 | SOLID BRONZE | 7 |
| 108 | " " | " | " | " | " | " | " | " | " | 12454 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | 512075 | " | " | " | " | " | 8 |
| 109 | CIRCULATING WATER (Cl₂) | " | | | | | | " | " | 12455 | " | 2 | 12½ | " | 1150 | 96 | " | " | " | 800 | " | 690 | 7½J | 5 | 512043 | 1150 | 370 | 315.00 | " | 9 |
| 110 | " " | " | " | " | " | " | " | " | " | 12456 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | 512035 | " | 370 | " | " | " | 10 |
| 111 | " " | " | " | " | " | " | " | " | " | 12457 | " | " | " | " | " | " | " | " | " | " | " | " | " | " | 512037 | " | 370 | " | " | " | 11 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 12 |

FIG. 2. A PORTION OF THE PUMP AND MOTOR SCHEDULE

This chart which contains the complete record of all pumps and their motors, installed in the plant, gives complete information in case of repair or replacement. It is revised from time to time as necessity demands.

This slack is taken up in the production of new machinery and improvements. Special check valves for vacuum pan drip outlets, valve stems and parts, special bolts and innumerable small parts for the sugar centrifugals and automatic starters are profitably made on the turret lathe.

Standard equipment such as the high speed dock cranes sometimes have to be rebuilt with their weak points strengthened according to home-made patterns. Manufacturers frequently are not in position to depart from their standards to fit special service so that revisions have to be made in the field. The shop does not build such standard machines as pumps, but special machines which break up the routine of an outside shop can be more economically built here. The convenience of cutting and welding tools is amazing especially to the man who had to do mechanical work say 25 yr. ago. These tools can do more pipe fitting during the Sunday shutdown than a squad of men can do in a week and besides do a much better job. Pipe connections to tanks are a simple chore. The scrap pile now furnishes raw material for many useful articles. Sometimes short scrap beams have been pieced together for use where loading was not too severe. Building beams that were difficult to remove have been reënforced in place by welding cover plates on the top and bottom flanges. Patches are welded to old tank bottoms to extend their life. Worn places in shafts are built up

The carpenter shop contains a rip saw, cross cut saw, band saw and planer and small electric hand saw; also a concrete mixer and electric hoist. This squad takes care of building repair work and is gradually replacing the wooden floors in the old buildings with concrete. When large sized building extensions are called for, the pile driving and concrete work are sublet to an outside contractor and the work gangs attend to the balance of the job.

Painters use air brushes which can be plugged into air lines distributed throughout the building. Great vigilance is required to prevent deterioration of steel where vapor and flue gases are present. In the furnace room of the char house the steel columns are sand-blasted, painted with red lead and covered with heavily reënforced concrete. Red lead is used for protecting all steel work and the most important time to paint it is when it is new and before rusting has commenced. It is a waste to paint over rusty surfaces.

For cutting pipe, the pipe shop is equipped with three pipe machines to cut 8-in. and smaller. When pipe above this size is required, a thread can for emergency be cut by the machine shop but usually it is purchased with vanstone joint from a nearby shop. Important lines are mostly welded so that few fittings are used.

One of the most versatile gangs is the house me-

chanics and riggers. These men keep the wheels going and make repairs. When a detail of machinery fails, an effort is of course made to establish the cause and then provide extra strength and quality to avoid recurrence. Repairs and time-out have thus been reduced so as to allow more time for the most important work of revising equipment to anticipate obsolescence. In recent years, this gang, together with the shop men, have built and installed new equipment that has reduced the operating force by over 100 men.

Ball and roller bearings are now used for conveyor idlers, blowers, motors, loose pulleys, belt tighteners during the metamorphosis! It is like a game of chess. The thinking is done during the week while the moves are made on Sunday.

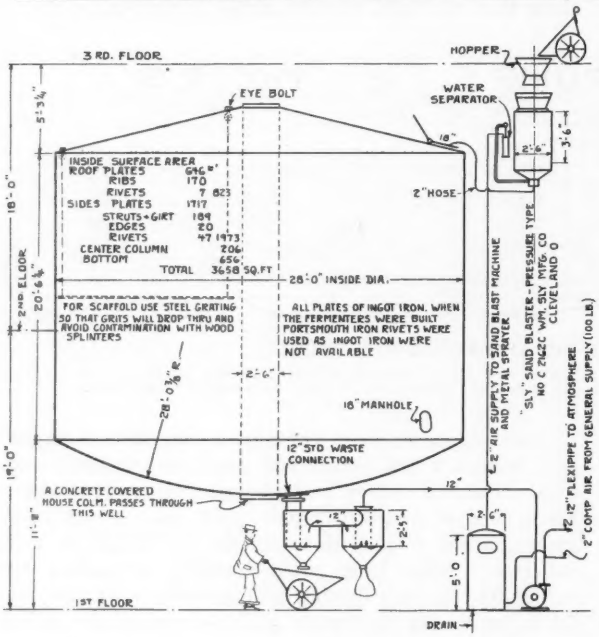
All of the wooden floors in the old buildings are gradually being replaced with concrete and steel and while this work is progressing, tanks and other equipment are rearranged to simplify the routing and to make more room. More machinery is hung from the ceiling to allow head room for traffic below. Old power transmission apparatus has been replaced with enclosed speed reducers, silent chains, Texropes and simple belts with idlers. The belts are found useful in many cases

## COST DATA

| FERM NO. | DATES 1926 START | DATES 1926 FINISH | AREA IN SQ.FT. | LABOR PER 100 SQ.FT. HOURS | LABOR PER 100 SQ.FT. COST | TIN PER 100 SQ.FT. LBS. | TIN PER 100 SQ.FT. COST | OXYGEN PER 100 SQ.FT. TANKS | OXYGEN PER 100 SQ.FT. COST | ACETYLENE PER 100 SQ.FT. TANKS | ACETYLENE PER 100 SQ.FT. COST | GRIT PER 100 SQ.FT. LBS. | GRIT PER 100 SQ.FT. COST | GRAND TOTAL COST | TOTAL COST PER 100 SQ.FT. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | MAY 3 | AUG. 10 | 3658 | 60.4 AT $0.669 | $40.40 | 45.3 AT $0.86 | $39.09 | 0.93 AT $7.56 | $7.10 | 0.74 AT $6.21 | $4.56 | 243 AT 0.647 | $15.72 | $3839.29 | $104.95 |
| 7 | AUG. 12 | " 28 | 206 | 198.0 " 0.657 | 130.00 | 87.3 " 0.75 | 66.83 | 1.5 " " | 11.01 | 1.5 " " | 9.04 | " " " | | 476.86 | 226.63 |
| 8 | " 31 | SEPT. 11 | " | 232.0 " 0.606 | 140.60 | 106.8 " " | 80.10 | 1.5 " " | 11.01 | 1.5 " " | 9.04 | " " " | | 528.35 | 256.45 |
| 4 | SEPT. 17 | OCT. 5 | " | 245.6 " 0.610 | 149.50 | " " " | " | 1.9 " " | 14.68 | 0.97 " " | 6.03 | " " " | | 548.94 | 266.21 |
| 5 | NOV. 15 | DEC. 10 | " | 265.5 " 0.617 | 163.90 | 121.3 " " | 91.02 | 1.9 " " | 14.68 | 1.5 " " | 9.04 | " " " | | 606.44 | 294.38 |
| 2 | DEC. 31 | JAN. 27 | " | 238.8 " 0.570 | 136.20 | 106.8 " " | 80.10 | 1.9 " " | 14.68 | 1.5 " " | 9.04 | " " " | | 520.60 | 252.71 |
| TOTALS | | | 4688 | 99.0 " 0.638 | 63.20 | 58.6 " .817 | 47.88 | 1.11 " " | 8.39 | 0.87 " " | 5.40 | 243 AT 0.647 | 15.72 | 66620.48 | $143.24 |
| 1 | JAN. 14 | JAN. 27 | 206 | COST NOT RECORDED | | | | | | | | | | | |

## REMARKS

THE COSTS DO NOT INCLUDE ELECTRICITY, COMPRESSED AIR, WORKMANS INSURANCE OR OTHER OVERHEAD. WHEN FERMENTER NO. 2 WAS COMPLETED THE EQUIPMENT WAS MOVED TO THE PAN FLOOR AND WORK ON THE LAST FERMENTER (NO. 1) POSTPONED. QUANTITY AND COST OF GRIT = TOTAL AMOUNTS DIVIDED BY TOTAL AREAS. THERE WAS A QUANTITY OF USED GRIT LEFT OVER WHICH HAD SOME VALUE FOR CLEANING BUT WAS NOT SHARP ENOUGH TO USE FOR PROPER PREPARATION OF THE SURFACE. GRIT USED WAS — ETC, ETC.


3RD. FLOOR
HOPPER
EYE BOLT
WATER SEPARATOR
INSIDE SURFACE AREA
ROOF PLATES 646 SQ.FT.
RIBS 170
RIVETS 7 823
SIDES PLATES 1717
STRUTS + GIRT 189
EDGES 20
RIVETS 47 1973
CENTER COLUMN 206
BOTTOM 656
TOTAL 3658 SQ.FT.
2"HOSE
28'-0" INSIDE DIA.
FOR SCAFFOLD USE STEEL GRATING SO THAT GRITS WILL DROP THRU AND AVOID CONTAMINATION WITH WOOD SPLINTERS
ALL PLATES OF INGOT IRON. WHEN THE FERMENTERS WERE BUILT PORTSMOUTH IRON RIVETS WERE USED AS INGOT IRON WERE NOT AVAILABLE
18" MANHOLE
12" STD WASTE CONNECTION
A CONCRETE COVERED HOUSE COLM. PASSES THROUGH THIS WELL
2ND FLOOR
1ST FLOOR
DRAIN
SLY SAND BLASTER - PRESSURE TYPE NO C 2162C WM. SLY MFG. CO CLEVELAND O
6" AIR SUPPLY TO SAND BLAST MACHINE AND METAL SPRAYER
12" FLEXIPIPE TO ATMOSPHERE
2" COMP AIR FROM GENERAL SUPPLY (100 LB)

## METAL COATING OUTFIT

| | |
|---|---|
| SAND BLAST MACHINE - W.W. SLY MFG. CO. CLEVELAND, O. NO. C 2162C (INCLUDES HOSE, GLOVES + HELMET) | 409.00 |
| EXHAUSTER NO. 2½ TROY TYPE, SIROCCO-AMERICAN BLOWER CO. | 90.00 |
| 5 HP MOTOR AT 1200 R.P.M. (IN STOCK) D.C. TO EXHAUSTER | 383.60 |
| CYCLONE DUST COLLECTORS - P.S. CO'S. TIN SHOP | 187.10 |
| FLEXIPIPE BEMIS BROS. BAG CO. 3-25' LENGTHS | 27.50 |
| "SUBWAY" SCAFFOLD GRATING 171 SQ FT. | 198.00 |
| METAL COATING TOOL (WITH ROYALTIES) METALS COATING CO. OF AMERICA | 1500.00 |
| AIR REGULATOR, HOSE FITTINGS, ACCESORIES " " " | 320.00 |
| TOTAL COST OF PLANT | 3115.20 |

PURE TIN WIRE NO. 13 B + S. GAGE ON 10 LB. SPOOLS BOUGHT FROM JOHN T. LEWIS & BROS. CO.

FERMENTERS NO 1, 2, 3, 4 WERE PLACED IN SERVICE NOV 20, 1924 - NO. 6, 7, 8 JULY 1926

## MAINTENANCE RECORD

| 1 | 2 | 3 |
|---|---|---|
| 1926 AUG. 8 TO 30 ALL RIVETS EXCEPT THOSE IN TOP COURSE OF SIDE PLATES, ROOF + CENTER COL WERE CUT OUT AND REPLACED WITH INGOT IRON RIVETS UNDER CONTRACT WITH ROBT PENNEWELL AS FOLLOWS 5663 LBS RIVETS AT 12½¢ + HR = 701.70 LABOR - 5780 RIVETS AT 18¢ + EXTRA WAITING TIME DUE TO LACK OF AIR FURN BY US - 1129.40 1826.10 | MAR 1928 - OLD RIVETS REPLACED WITH INGOT IRON, SAME AS NO 1 5738 AT 18¢ = $1037.80 | APR 1928 OLD RIVETS REPLACED WITH INGOT IRON, SAME AS NO. 1 5728 AT 18¢ = $1030.14 |
| 1927 JAN. 14 TO 28 CENTER COL SPRAYED WITH TIN | | |

FIG. 3. SHOWING METHOD BY WHICH COST DATA AND MAINTENANCE COSTS ARE RECORDED

This drawing shows the manner in which the data are kept, although the arrangement of items has been altered to facilitate making a small cut.

and shafting. A short conveyor in the char house where there is much dust and heat had 40 rollers, each of which required two oilings per day to prevent heating. This makes 160 drops daily or 48,000 per yr. The ball-bearing idlers which replaced these are greased with the aid of a gun about three times a year, making 480 applications. The change to anti-friction bearings has saved $10,800 annually in labor and $1600 in grease.

Some years ago, the house gang installed in the old melter house a steel, hopper-bottom bin to hold 1000 t. of raw sugar for the night requirements of the plant. This job required a space extending from the fifth floor through the roof above the eighth and called for reënforcing the steel columns to the foundations as well as the driving of 150 piles in the cellar. The fascinating part of these jobs consists in keeping the plant going to absorb the shock and their life is extended by relieving the surplus load with an idler. The idlers are ball-bearing, loose pulleys whose home-made frames and supports are burned out of the scrap pile.

Recently the house gang (et al) has installed a Ruths accumulator weighing 500 t. on the roof of the Pan House (above the eighth floor).

### Use of Manlifts Saves Time

While much conveying equipment was installed for handling materials, manlifts were also provided so that they are now nearly as numerous as stairways. These lifts are endless vertical 12-in. belts having shelves and handles spaced about 20 ft. centers and moving from 70 to 100 ft. per minute. The workman steps on the shelf on either the up or down-going belt and takes

the handle. An automatic device stops the belt in case the passenger forgets to get off at the top. He can also stop the machine instantly by means of a safety rope.

In the electric shop there is installed a lathe, drill, electric bake oven, 50-ton press, coil puller, coil winder and armature winding machine. This shop makes all electric repairs and occasionally special devices. The operating equipment includes four 500-kw., 230-v., d.c. generators and one 1000-kw. unit connected to Corliss engines. In the plant there are 476 motors of which 60 are stand-bys and there are 70 spares in the store room. The horsepower varies from the small sewing machine motors to 200 hp. All motors bought within the last 2 yr. came with ball or roller bearings. All older motors have been rebuilt with ball and roller bearings so that there are now no sleeve bearings left in the plant.

### Motor Routine

Operating routine calls for one inspection daily of every motor by an electrician appointed to this job. The oiler (who belongs to the house mechanics gang) as well as the station operator also reports to the electric shop any unusual behavior of the motors. Another electrician goes over all of the motors twice a week with a blower, either portable or using a hose attached at the compressed air header.

Three times a year the shop machinist cleans out and refills all of the bearings. About 10 da. is required for this job. No record is kept of this kind of work as it is a regular routine; however, a record is kept of the winding of fields and armatures.

Some years ago the life of some of the home-wound fields was not satisfactory and it was concluded that the device used for keeping the wire taut did not keep an even tension so that sometimes the wire was pulled too tight. The new device made by the shop machinist now keeps an even tension on the wire and simultaneously measures the length. The antifriction bearings, together with the regular attention to cleaning has greatly reduced the repairs. Armature winding is not now a frequently recurring job. Two or three of the gang are highly skilled at the practice but all of them can do it if necessary. The electrical gang does new wiring for alterations as well as for new buildings. When a motor fails, a new one of the same size and make is quickly set in its place. The reasons for standardizing on one make of motors are difficult for competing salesmen to understand, but when a unit which has no stand-by fails, while the production department is "hollering," it is a great convenience to the repair gang to have on hand a standard motor.

### Store Room Practice

The store room contains stores, spare parts and tools. The tools now available are as wonderful as Aladdin's lamp. Tools are charged out by the McCaskey System which consists of paper memos in duplicate which are signed by the workman, one copy being retained by himself. If a tool is not returned because of an allegation of loss, the price of it is deducted from the workman's wages. This has occurred only a few times but the effect of it has made the loss of tools almost negligible.

A constructor is accustomed to seeing vigorous activity on his job and he knows that the lack of this on the part of the workmen is due to the lack of foresight and vigilance on the part of himself or his supervisors. When the gang is a mixture of operators and constructors, it is essential to be prepared with lists, plans and sketches of a variety of jobs so that foremen can synchronize the time, job and man without hesitation. The specialty gangs are small and occasionally require reënforcements from other gangs. If there is a delay in the arrival of a ship, the dock men fall in line under the leadership of the head carpenter and four concrete men and place concrete almost as economically as a regular concrete gang. A 72-in. by 18-ft. return tubular boiler was left over from the remodeling of the cooper shop. The boiler house operators cut out the tubes, riveted new bumped ends onto the shell and installed the tank for an air receiver. As only spare time could be employed, it took over a month to do the job and the Accounting Department had a charge of $500.00. A new tank not so well made could have been bought for $650.00. If someone had not thought of that boiler, production would have cost $500.00 more that month and an additional expenditure of $650.00 would have been required to provide the luxury of a good air receiver.

FIG. 4. ACCUMULATOR FOR 150 LB. PRESSURE, WEIGHING 500 T., ERECTED ON ROOF OF PAN HOUSE BY MAINTENANCE CREW

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Because of the large amount of leather belting used, the American Society of Mechanical Engineers has asked the American Engineering Standards Committee to authorize the establishment of definite standards for leather belting as applied to the industrial purchaser. This proposal is now being considered by the Executive Committee of the Standards Committee. If approved, the work will be undertaken shortly, covering quality, capacity, weight, care and maintenance of belting.

Precedence for belting standardization is found in the work of the American Petroleum Institute, which has established standards for all types of belting used in the oil industry. It is estimated that the specifications and recommendations of the Institute have increased the value of belting purchases in the oil industry by 25 per cent. The saving of all industries on this basis would mean that the purchasers of leather belting in the United States would be saved over $7,000,000 annually.

# Diesel Powered Municipal Pumping Plant

CHANGE FROM STEAM TO DIESEL POWER RESULTS IN INCREASED OUTPUT AT REDUCED COST AT THE KEARNEY WATER PUMPING STATION

KEARNEY, NEB., originally had a privately operated water pumping plant which was built in 1886. The city purchased the plant in 1911 at a cost of $125,000. This consisted of direct acting steam pumps and horizontal return tubular boilers. Coal, in recent years has cost $5.64 a ton and as the pumps required from 150 to 200 lb. steam per hp., it is evident that the plant was completely out of date.

### CITY INSTALLS DIESEL ENGINES

In 1924 two 300-hp. De LaVergne Machine Co., four-cycle, solid fuel injection Diesel engines, operating at 80 per cent machine load factor and direct connected to 3-phase, 60-cycle, 250-kv.a. Westinghouse generators with 13-kw., 125-v. shunt wound d.c. exciters operating at 225 r.p.m. were installed. Tests made on these engines gave the following low fuel consumptions:

| Load | Fuel Consumption |
|---|---|
| Full | 0.421 lb. per br.hp. |
| ¾ | 0.436 lb. per br.hp. |
| ½ | 0.488 lb. per br.hp. |
| ¼ | 0.620 lb. per br.hp. |

In testing the engines for overload capacity, 384 b.hp. was satisfactorily carried on each unit without trouble and as the effect of the high altitude of 2200 ft. above sea level would be to reduce the effective capacity of the engines, the liberal rating of the engines is apparent. Three American Well Works single-stage horizontal centrifugal pumps, having a capacity of 50,000 g.p.h., are each direct connected to a 60-hp. Westinghouse motor running at 1750 r.p.m.

### INFLUENCE OF DIESEL PLANT ON RATE REDUCTION

Previous to the building of the power plant, the city paid 11½ cents per kilowatt-hour to the Central Power Co. for its lighting service. Just after the plant was started, this rate was cut to 9 cents. When the street lighting contract ran out in July, 1927, the rate was cut further to 1 cent for this service and 3 cents for lighting of municipal buildings. These latter rates became the bases of a 10-yr. contract with the city and since the poles and lines in the streets belong to the Central Power Co., the service of the power plant was confined to water pumping and efforts toward municipal lighting were abolished.

Pumping operations are carried on only about 6 hr. in 24 during the winter and 15 hr. in 24 during the summer in order to fill the reservoir each day. When running, the load is steady and the engines operate at from 55 to 60 per cent of their rated load, only one engine being used at a time. The uniformity of load is illustrated in the flow chart, Fig. 2, which is recorded on a Republic flow meter. In using this chart, the values represented are multiplied by the factor 12 in order to obtain the quantity of water pumped. For example, at 2:30 p. m., 60 × 12 = 720 g.p.m., was pumped. The water level chart, Fig. 3, indicates that on the day specified the pumps operated 7 hr. in order to raise the level from 6½ to 11¼ ft.

### RESERVOIR ACTS AS SURGE TANK

Water storage capacity of 1,000,000 gal. is held in a reservoir which is located on a 100-ft. high hill, 1½ mi. from the pumping plant. This reservoir is built of concrete and is 110-ft. diam. and 14½ ft. deep. It has a concrete roof covered with 1 ft. of soil. The pressure on the system is held at about 50 lb., the reservoir being connected in the system acting as a surge tank. As no reservoir was used in connection with the old steam plant, it pumped direct into the line and the pressure varied from 15 to 40 lb.

Fuel oil is stored in a 12,000-gal. steel tank which is located under ground. Tank cars are unloaded by gravity from a railroad siding 150 ft. from the tank. Light oil of from 32 to 34 deg. Beaumé grade being used, necessity for heating in order to handle it is avoided. A No. 3 Deming oscillating handle oil pump is used to transfer the oil from the reservoir tank to the daily fuel oil supply tanks located at the engines.

De LaVergne oil reclaimers are used to clarify used lubricant. Standard Oil Co. Nonpareil Diesel lubricating oil at 64 cents a gallon is used and over 3000 hp-hr. are developed per gallon.

Starting air at 150 to 200 lb. pressure is used. This is stored in three receivers 24 in. diameter and 10 ft. long. They are usually filled by the engines just after starting but, for emergency purposes, a Worthington vertical air compressor, driven by a 6-hp. Ingeco Engine Works gasoline engine, is installed. This compressor can furnish air up to 210-lb. pressure.

Efficient management of the plant is secured through use of a complete equipment of indicating and recording instruments and costs are carefully kept. Repair

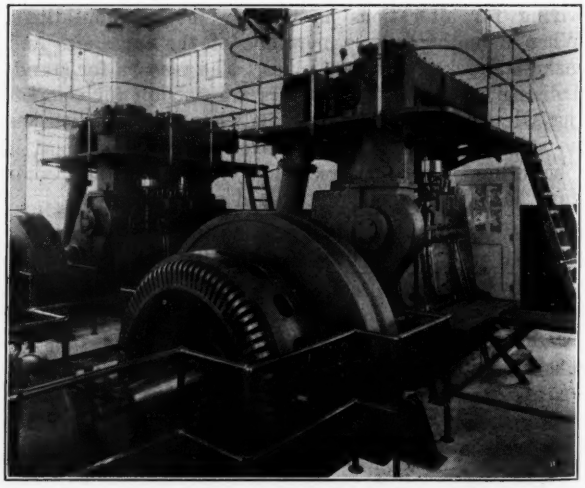

FIG. 1. THREE-HUNDRED-HORSEPOWER DIESEL ENGINES FURNISH POWER FOR ELECTRICALLY-DRIVEN PUMPS IN CITY WATER WORKS

costs have been almost negligible, the only repair made during the past year being that of keys for the sprocket of the cam shaft.

Summary of operating costs for the years 1924-1926-1927 is given in the table. The year 1924 was the last full year that the old steam plant was operated alone. During 1925 both steam and Diesel power were used, hence the cost summary is omitted for this year.

SUMMARY OF REVENUE AND COSTS

| | |
|---|---|
| **1924** | |
| Water pumped—gallons | 323,581,000 |
| Water revenue | $25,470.45 |
| Fuel cost | 7,998.56 |
| Labor cost | 3,360.00 |
| Lubricating oil cost | 280.00 |
| Total | $11,638.56 |
| Fuel consumed, coal, lb. | 2,835,200 |
| Average cost per ton | $ 5.64 |
| **1926** | |
| Water pumped—gallons | 327,033,360 |
| Water revenue | $31,475.97 |
| Fuel cost | 2,513.30 |
| Labor cost | 2,316.00 |
| Lubricating oil cost | 183.63 |
| Total | $ 5,012.93 |
| Fuel consumed, oil, gallons | 37,835 |
| Average cost per gallon | $ 0.066 |
| **1927** | |
| Water pumped—gallons | 342,824,800 |
| Water revenue | $29,489.52 |
| Fuel cost | 2,658.52 |
| Labor cost | 2,390.00 |
| Lubricating oil cost | 173.64 |
| Total | $ 5,222.16 |
| Fuel consumed, oil, gallons | 41,744 |
| Average cost per gallon | $ 0.064 |

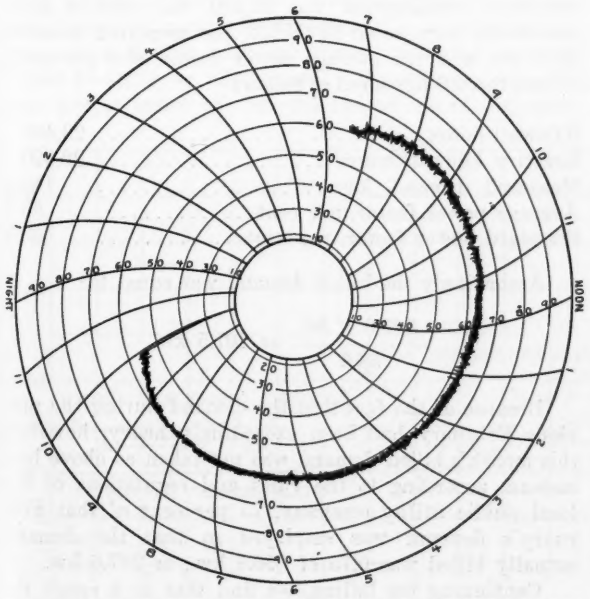


FIG. 2. PUMPING LOAD ON ENGINE IS CONSTANT DURING TIME OF SERVICE

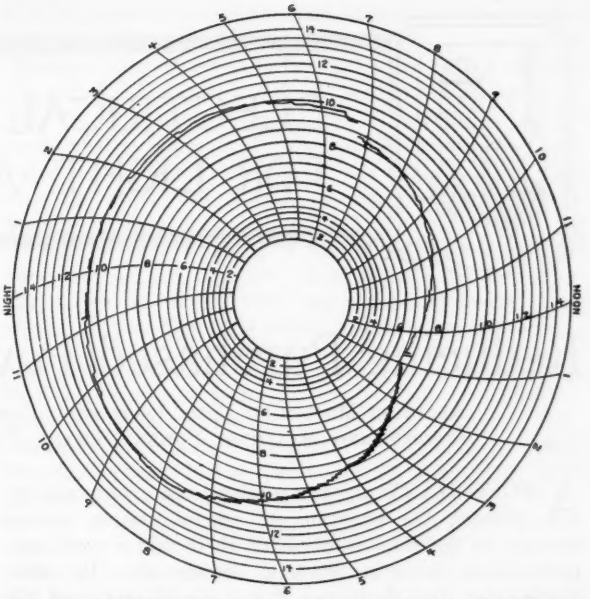


FIG. 3. RECORDING LEVEL GAGE SHOWS HEIGHT OF WATER IN RESERVOIR AT ANY TIME AND INDICATES PERIOD WHEN PUMP WAS IN ACTION

As shown by the record, nearly as much water was pumped by the old plant as by the new, but in changing from old to new it was found that the old piston pumps were over registering nearly 25 per cent. This is shown in the increased revenue from the new plant.

Levy made for the city's public water is not shown in the summary. In 1924 a levy of $12,000 was made for this purpose and also one of $2500 to cover interest on the old waterworks bonds. In 1926 the City Council reduced the $12,000 levy to $10,000 and in 1927 the levy for $2500 was dropped. The interest on the new water works bonds is now being paid and it is expected that the new bonds will be paid off at the rate of $20,000 each year.

Costs for labor, fuel and lubricating oil have been reduced about $6000 each year. The revenue has been increased $5000, due to the ability of the plant to supply all of the water requirements of the city. This makes a gain to the city of $11,000 a yr.

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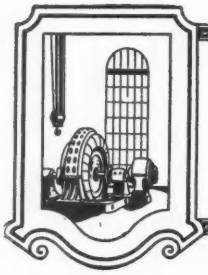
CONSUMERS' STOCKS OF BITUMINOUS COAL on July 1 amounted to 41,700,000 t., according to the latest survey by the Bureau of Mines, Department of Commerce. In comparison with the quantity on hand at the beginning of the previous quarter this is a decrease of 6,600,000 t. The abnormal reserves built up in anticipation of the suspension of mining on April 1, 1927, have now been largely absorbed and the present stocks are not far from those at the corresponding period in 1925 and 1926.

As usual at this period of the year there was a sharp decline in the rate of consumption following the end of the heating season. The average consumption for the second quarter, excluding exports, was 8,312,000 t. per week, as against 10,636,000 t. in the first quarter. A decrease is also shown in comparison with the second quarter of 1927, when consumption averaged 8,889,000 t. a week.



# ELECTRICAL MACHINERY FOR LIGHT AND POWER

# Reducing Purchased Power Costs in a Steel Plant

ADAPTING MOTORS TO LOAD, INCREASING POWER FACTOR, STUDYING AVAILABLE RATES AND CONTROLLING MAXIMUM POWER DEMAND PAY BIG DIVIDENDS. BY OTTOMAR H. HENSCHEL

AMONG MANY plant executives and even some engineers, the adoption of central station service appears as the final solution of their power problems, particularly from a financial standpoint. In other words, they feel that once they have discontinued the operation of their own power plant and instead are securing their supply of electric energy from the outside, the lowest costs possible have been secured; however, such is frequently, no, many times, not the case at all.

Unless the attention of such executives and engineers is called to the fact that central station companies have, as a rule, various classes of service and corresponding rates and that further, such public utilities, as a rule, heavily penalize, in some way, customers whose installations operate at a low power factor, costs higher than necessary are likely to be encountered. In fact, it is readily possible that, unless proper rates are employed, a high power factor maintained and the demand held down to a minimum, purchased energy may cost considerably more than it would if generated locally, especially in the event that steam may be required for heating and (or) manufacturing processes.

Let us take the case of a comparatively small manufactory located in the middle west where extremely favorable utility rates are in existence. This plant, which is devoted to the making of heavy steel punchings and stamping primarily for the automobile industry, is served by means of 13,200-v., three-phase, 60-cycle system, the high voltage being stepped down to 440 v. through the medium of a single three-phase oil-cooled transformer. The connected power load of approximately 1200 hp. is made up of about 100 motors ranging in size from ¼ to 150 hp.

Five or six years ago, in spite of the fact that the institution in question had a considerable demand for steam for both heating and process,operation of the power plant (that is, the engine and generator) was discontinued and central station service substituted under the unlimited primary metering rate. Then, during the year 1922, which was one of the first under the new order, the kilowatt-hour consumption, the cost per kilowatt-hour and the power factor were as shown graphically in Fig. 1, and, as will be noted, due to over motorization of the plant, the power factor was exceedingly low. The effect of this low power factor alone may be well illustrated by citing a typical month's billing when the kilowatt-hour consumption was 23,400, the reactive kilowatt-hours were equal to 29,520, the measured demand 146.8 kw. and the average power factor 56.6 per cent, so that the bill appeared as follows:

| | |
|---|---|
| Kilowatt-hours | 23,400 |
| Reactive kilowatt-hours | 29,520 |
| Measured demand, kw. | 146.8 |
| Average power factor, per cent. | 56.6 |
| Standard power factor, per cent. | 80.0 |

Accordingly the billed demand was equal to:

$$\frac{146.8 \times 80}{56.6} \text{ or } 207.5 \text{ kw.}$$

Because of the fact that the demand during the previous February had been exceedingly heavy, however, this month's billed demand was not taken as above but, instead, according to the rules and regulations of the local public utility company, 75 per cent of that February's demand was employed so that the demand actually billed was 0.75 of 396.9 kw., or 297.6 kw.

Continuing the billing, we find that as a result the demand charge was

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| | |
|---|---|
| Demand charge: | |
| 200 kw. at $2.00 per kilowatt per month | $400.00 |
| 97.6 kw. at $1.50 per kilowatt per month | 146.55 |
| | $546.55 |
| Energy charge: | |
| 23,400 kilowatt-hours at 1¼c | $292.50 |
| | $839.05 |
| Discount | 9.37 |
| | $829.68 |
| Coal factor addition | $ 39.31 |
| Net | $868.99 |

During August, 1921, however, the power factor had been as low as 31 per cent so that, under such a power factor, the demand billed would have been much more, or 146.8 × 80 ÷ 31 = 378.8 kw., thus resulting in a demand charge of

| | |
|---|---|
| 200 kw. at $2.00 per kilowatt per month | $400.00 |
| 178.8 kw. at $1.50 per kilowatt per month | 268.20 |
| or, a total of | $668.20 |

thus indicating a saving due to increased system power factor equal to the difference between $668.20 and the demand charge which was made, of $546.55, or $121.65, or an average of $1459.80 for the year.

In other words, with a given energy consumption and measured demand increasing the power factor from 31 to 56.6 per cent, the annual reduction in power cost amounted to nearly $1500.00.

### Remotorization Increased Power Factor

At this point, it is interesting to note that this increase of power factor was brought about only by a remotorization of the plant equipment, at practically no expense except a comparatively small labor charge. The large motors were traded in for units of a smaller size and obviously no changes in the wiring were necessary.

Since that time, however, by further remotorization (which did involve the purchase of some few especially designed high-torque motors for use in connection with some of the punching and forming presses) and the installation of power factor corrective equipment (in this case a static condenser) the power factor has been raised to unity, or 100 per cent. Accordingly, had this high power factor existed and the effects of the excessive February demand not been brought into consideration, the billing would have been

Demand 146.8 × 80 ÷ 100 = 117.4 kw. with a demand charge of 117.4 kw. at $2.00 per kw. per month = $234.80, so that, as a result, the difference in the demand charge, consequently the net bill, would have been equal to $546.55 — $234.80 = $311.75. At that monthly rate, the yearly savings would naturally amount to $3741.00.

Let us now consider a higher kilowatt-hour consumption as, for instance, such as took place during the month of March, 1926, when 101,520 kw-hr. were used. At that time, the billing appeared as follows:

| | |
|---|---|
| Kilowatt-hours | 101,520 |
| Reactive kilowatt-hours | 32,400 |
| Measured demand, kw. | 302 |
| Average power factor, per cent | 93.8 |
| Standard power factor, per cent | 80.0 |

So that the billed demand was equal to

$$302 \times 80 \div 93.8 = 257.6 \text{ kw.}$$

with the result that the demand charge was

| | |
|---|---|
| 200 kw. at $2.00 per month per kw. | $400.00 |
| 57.6 kw. at $1.50 per month per kw. | 86.40 |
| | $486.40 |

and the energy charge

| | |
|---|---|
| 25,000 kw-hr. at 1.25c per kw-hr. | $312.50 |
| 25,000 kw-hr. at 1.10c per kw-hr. | 275.00 |
| 50,000 kw-hr. at 1.00c per kw-hr. | 500.00 |
| 1520 kw-hr. at 0.90c per kw-hr. | 13.68 |
| | $1101.18 |

| | |
|---|---|
| thus making a combined demand and energy charge of | $1587.58 |
| The discount was | 16.88 |
| And the coal factor deduction | 76.14 |
| With the result that the net bill for that particular month was equal to | $1494.56 |

Let us now see what this bill would have amounted to, had no attempt been made at power factor correction; that is, had it been the same as in August, 1921, namely, 31 per cent.

We would then have had a billed demand of

$$302 \times 80 \div 31 = 778.3 \text{ kw.}$$

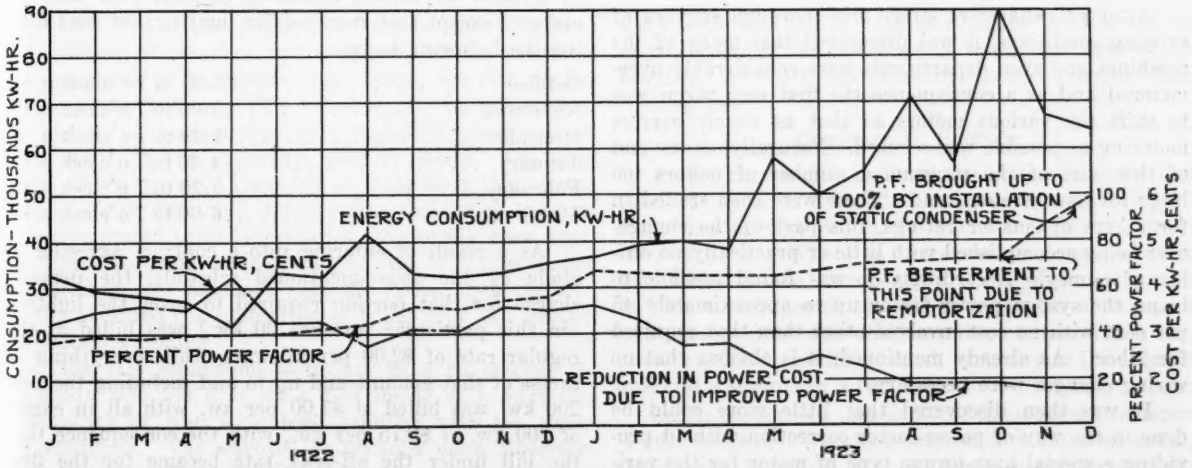
CONSUMPTION - THOUSANDS KW-HR.
PERCENT POWER FACTOR
COST PER KW-HR, CENTS
ENERGY CONSUMPTION, KW-HR.
P.F. BROUGHT UP TO 100% BY INSTALLATION OF STATIC CONDENSER
P.F. BETTERMENT TO THIS POINT DUE TO REMOTORIZATION
REDUCTION IN POWER COST DUE TO IMPROVED POWER FACTOR
J F M A M J J A S O N D J F M A M J J A S O N D
1922
1923

FIG. 1. TYPICAL POWER COST DATA FOR THE YEARS 1922 AND 1923, SHOWING THE REDUCTION IN UNIT COST WITH INCREASED POWER FACTOR

with a demand charge of

| | |
|---|---|
| 200 kw. at $2.00 per month per kw. | $ 400.00 |
| 578.3 kw. at $1.50 per month per kw. | 867.45 |
| or, | $1267.45 |
| As above, the energy charge would be | 1101.18 |
| So that the combined demand and energy charge would be | $2368.63 |
| The discount | 24.68 |
| And the coal factor deduction | 76.14 |
| With the net bill equal to | $2,267.81 |

Thus, it is evident that by raising the system power factor from the original value of 31 per cent to 93.8 per cent the saving in energy cost for this month alone was equal to the difference between $2,267.81 and

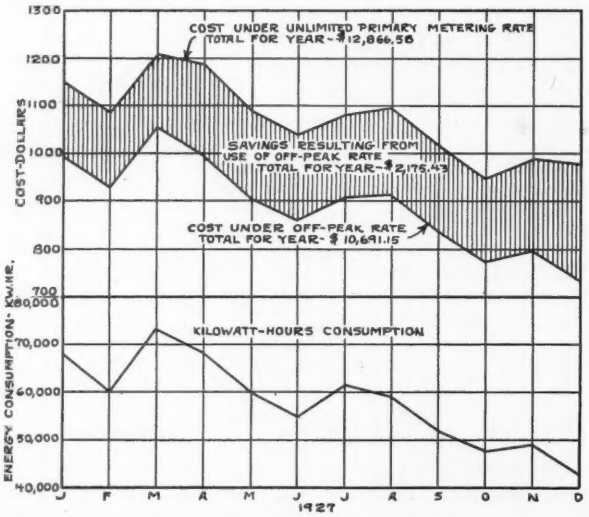


FIG. 2. ILLUSTRATING GRAPHICALLY SAVINGS RESULTING FROM EMPLOYMENT OF THE OFF-PEAK RATE

$1,494.56 or, $773.25. At the same rate of consumption, demand and power factor for a one-year period the annual saving would be $9,279.00.

### Cost of Savings Produced

Naturally anyone of an inquisitive turn of mind would ask, "Just how much did it cost to bring about these reductions in power costs?"

After an exhaustive study and thorough surveys of existing conditions, it was discovered that many of the machines and even departments were considerably overmotored and as a consequence the first step taken was to shift the various motors so that as nearly correct motoring as possible was secured. Naturally, at the end of this part of the program a number of motors too large for use were on hand. These were then traded in for others of smaller ratings, this part of the changeover being accomplished with little or practically no outlay of money. Accordingly it was found possible to bring the system power factor up to approximately 45 per cent with no cost involved other than that required for labor. As already mentioned, it is obvious that no wiring changes were necessary.

It was then discovered that little more could be done in the way of power-factor correction without providing a special high-torque type of motor for the various power presses and accordingly, after some experimentation, a motor was secured which could operate the presses at a favorable degree of capacity and power factor and still start the machines within a minimum period of time. When these special motors were in operation, it was found that under normal conditions the power factor was about 70 per cent, 10 per cent below the penalization standard of 80 per cent. Subsequently a static condenser of sufficient capacity was purchased and installed. This, under ordinary conditions, was and still is able to raise the average monthly power factor to approximately 100 per cent.

Using the steel company's machinery numbers in designating the various units, the cost of the changes made was as follows:

| | |
|---|---|
| Remotoring press No. 3 | $ 156.20 |
| Remotoring press No. 28 | 104.30 |
| Remotoring press No. 52 | 139.45 |
| Remotoring press No. 90 | 168.61 |
| Remotoring press No. 50 | 82.77 |
| Remotoring press No. 51 | 98.48 |
| Remotoring press No. 5 | 122.59 |
| Remotoring press No. 108 | 268.09 |
| Remotoring press No. 58 | 269.02 |
| Remotoring press No. 49 | 101.28 |
| Remotoring press No. 6 | 114.20 |
| Remotoring press No. 80 | 127.12 |
| Remotoring press No. 89 | 118.16 |
| Initial cost of 6 special motors at $177.50 each | 1065.00 |
| Initial cost of static condenser | 1800.00 |
| Cost of installing condenser | 311.46 |
| Total cost | $5046.73 |

Reviewing the savings enjoyed over a period of years, it is found that the average is $530.55 each month, or $6366.60 a year; accordingly, the average returns per year are 126 per cent, an equipment investment not often presenting itself. It is, however, a typical example as to what can be accomplished in the average plant when problems of such kind are properly solved.

### Further Reductions Realized

Investigation into the matter of local rates revealed the fact that with a slight adjustment of plant operating schedules it was possible to secure an off-peak rate. Under this schedule, it is necessary, during the months of October to March, inclusive, of each year that no energy (except that required for lighting) be used during the following hours:

| | |
|---|---|
| October | 5:30 to 7 o'clock p. m. |
| November | 5:00 to 7 o'clock p. m. |
| December | 4:30 to 7 o'clock p. m. |
| January | 4:40 to 7 o'clock p. m. |
| February | 5:20 to 7 o'clock p. m. |
| March | 6:00 to 7 o'clock p. m. |

As a result of entering into a contract agreeing to abide by the above-mentioned schedule, the demand charge for that portion required to cover the lighting (in this particular instance 20 kw.) was billed at the regular rate of $2.00 per kilowatt, while everything in excess of that amount and up to and including the first 200 kw. was billed at $1.00 per kw. with all in excess of 200 kw. at $0.75 per kw., with the consequence that the bill under the off-peak rate became for the first month, namely, September, 1926, as follows:

Kilowatt-hours .....66,240
Reactive kilowatt-hours ..... 1080
Measured demand, kw..... 250.5
Average power factor, per cent..... 100
Standard power factor, per cent..... 80
Accordingly the billed demand was

$$250.5 \times 80 \div 100 = 200.4 \text{ kw.}$$

With the demand charge
20 kw. at $2.00 per kw.....$ 40.00
180 kw. at $1.00 per kw..... 180.00
0.4 kw. at $0.75 per kw..... 0.30
Making a total demand charge of.....$220.30
The energy charge was
25,000 kw-hr. at 1.25c per kw-hr.....$312.50
25,000 kw-hr. at 1.10c per kw-hr..... 275.00
16,240 kw-hr. at 1.00c per kw-hr..... 162.40
Resulting in a total energy charge of.....$749.90
Deducting the discount of $10.70 and the coal factor deduction, the net billed was.....$897.90

By this time, it will be obvious to the reader that both the power-factor penalization and the type of rate employed affect only the demand charge and not in any way the energy charge.

Let us now make a comparison of this bill with what it might have been had (a) the unlimited primary metering rate (that previously in use) been employed and then with (b) what it would have been had the original power factor still existed.

Taking case (a) the demand charge would be
200 kw. at $2.00 per kw.....$400.00
0.4 kw. at $1.50 per kw..... 0.60
Thereby making a total demand charge of.....$400.60
and resulting in a net saving (except a minor difference in the discount) equal to $400.60 — 220.30 = $180.30 for a single month. At the same rate of power consumption, demand and power factor, the net annual reduction of energy cost was equal to $2163.60.

Now, with the original power factor of 31 per cent we would have had a billed demand of

$$250.5 \times 80 \div 31 = 646.4 \text{ kw.}$$

with a demand charge of
200 kw. at $2.00 per kw.....$ 400.00
446.4 kw. at $1.50 per kw..... 669.60
With a total demand charge equal to.....$1069.60

Accordingly, it is obvious for a typical month such as that just cited, that by going over to the off-peak rate the savings resulting (however, disregarding slight differences in discount) are equal to the difference between $400.60 and $220.30 or, $180.30 and that further, by bringing the power factor up to 100 per cent, the net savings amount to $1069.60 — $220.30 = $849.30.

Thus the financial advantages of operating at a maximum degree of power factor are evident.

### Eliminating High Demands

As will be noted from the foregoing, the demand charge actually imposed is dependent firstly, upon the degree of system power factor as maintained and secondly, upon the demand measured. Ways and means by which the former may be raised as high as possible have already been discussed. The latter may be reduced to a minimum only by a little care in operation of the plant equipment.

Ordinarily plant executives give no attention whatsoever to the demand measured phase of power costs; nevertheless it has a decided bearing upon the ultimate number of dollars and cents paid to the utilities each year. Load peaks must be avoided as much as possible and it is the duty of the works manager, or his assistants, to see that during no 15-min. period (or whatever other period of time may be employed in the measurement of the demand) all of the machines be operated simultaneously. Care must be taken if the load curve is to be maintained reasonably uniform during the working hours. Naturally, this is a problem which each plant executive must solve for himself; no set rules or formulas can be given.

# Electricity---What It Is and How It Acts*

Part IX. Effect of Temperature Upon the Resistance of Solid Conductors. Factors Controlling Resistance

THERE IS A prevailing belief that science is cold—devoid of romance and religious feelings and that the scientist is an unemotional being, scarcely to be classified as human. This belief is due in a measure, no doubt, to the fact that the scientist has always kept to himself, first by necessity, later by choice. The first men of science were regarded as little more than emissaries of the devil and it was worth their very lives to venture out of their laboratories. Naturally they kept to themselves and as they had no end of things to interest them, the populace were the losers. But the scientist acquired the reputation of being cold and devoid of religious feeling.

That this reputation is unjust must be evident to anybody who has ever set a foot inside of a scientific laboratory or who is at least familiar with the work of scientists. The scientist is perhaps more sincerely religious than many of his critics; his religion may be a different kind and not open to display but if a sincere appreciation of the universe in which we live—of its beauties, its truth, its harmony, is not religion, then nothing is.

*All rights reserved.

### Romance in Science

As for romance, it lurks at the bottom of every test tube. It is to be found in the eyepiece of every telescope and microscope, in the evacuated space of every vacuum tube. Where is there greater romance than that which is the astronomer's when his spectroscope unfolds a tiny pencil of light from a star a thousand light years away and discloses the nature of the elements on that star with as much certainty as the chemist analyzes a sample in a test tube.

So, in the pursuit and study of the electron, romance is ever present. Who, contemplating a block of metal, could have imagined that its impenetrable mass consists almost entirely of space—that what matter there

is, is in unceasing motion and that the small particles within the boundaries of its surfaces have been whirling about at incredible speeds since the beginning of time?

### Electron at the Root of All Phenomena

The electron, we have seen, is at the root of all phenomena; it governs the characteristics of all elements and is the basis of all chemical activity; therefore it is at the basis of life itself. There can be little doubt that all biological phenomena are explainable in terms of the electron.

Seemingly tiny particles, endowed with incredible amounts of energy moving in accordance with inviolable law, they form the building blocks of the universe. What they are, outside of the fact that they represent the ultimate electrical charge, we do not know. Sometimes behaving as waves, at other times as particles, always giving rise to wave phenomena, they harbor the ultimate secret of the universe. In gases, in solids, in liquids, they always seem the same; the electron from one substance is the same as from another. They are everything and explain everything.

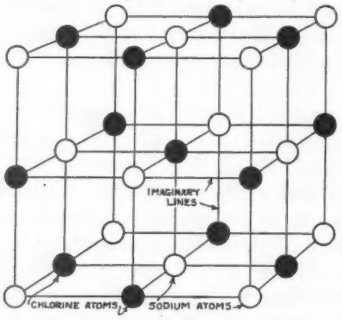


FIG. 1. CUBIC CRYSTAL STRUCTURE OF SODIUM CHLORIDE

This structure is typical of many substances. If the crystal is that of common salt, the black circles represent the sodium atoms and the light circles the chlorine atoms.

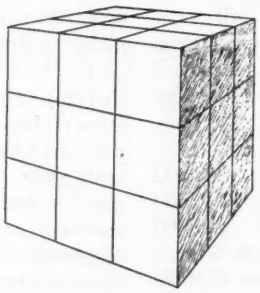

FIG. 2. BY ARRANGING CUBES IN REGULAR ORDER AND IN LAYERS, THEY CAN BE MADE TO FILL THE CONTAINER ENTIRELY

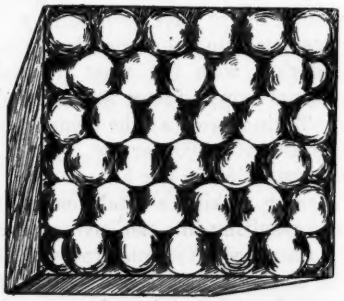

FIG. 3. SPHERES WILL FILL ONLY A PORTION OF THE TOTAL VOLUME OF A CONTAINER

In these articles, we have barely touched upon the multitudinous activities of the electron. We have described how they effect conduction in gases by ionizing normal atoms, how in liquids they govern chemical action and production of ions, and how in solids they effect conduction by jumping from atom to atom. Later we shall see how they are responsible for the production of light and x-rays, how they give rise to radioactive phenomena and many other things. First, however, we shall discuss the part they play in governing resistance in solids and in determining whether a solid is a conductor or an insulator.

### Effectiveness of Conduction Dependent Upon Spacing of Atoms

In the preceding article, conduction in solids was compared to the action of a large number of players on a basketball court in tossing balls around. In considering this analogy, it must be evident that the effectiveness of conduction of balls is dependent to a certain extent upon the amount of space between the players and upon their relative motion with respect to each other.

If the players are close together and remain stationary, the balls will be passed from one end of the court to the other with the least effort and with the least commotion. If, however, they should become excited and jump around a great deal (keeping within their assigned radius of action), thereby suffering many collisions among themselves, or if they should spread out so as to make it necessary to throw the balls farther, conduction would become less effective.

### Variation of Resistance with Temperature

This is exactly what happens in a solid conductor when the temperature is raised. As has been shown[1], even at ordinary temperatures the atoms of a solid are in incessant vibration. As the temperature is raised, more kinetic energy is imparted to the atoms and this vibration becomes more violent, thereby lengthening the mean free path between collisions. Under these conditions, as in the case of the basketball players, more energy is required to shoot an electron from one atom to another, making it more difficult to pass a given number of electrons in a given time. Thus we say that the resistance of the metal has increased with the temperature, a fact which has long been known to the electrical men from everyday experience. Most substances undergo an increase in electrical resistance as the temperature rises.

Naturally, the converse is equally true; as a metal is cooled, the kinetic energy of the atoms becomes less and the amplitude of vibration decreases. The atoms require less space and the metal contracts. In this condition, the passage of electrons is greatly facilitated, since the external orbits of the atoms tend more and more to overlap, thereby neutralizing the forces acting on the electrons in those orbits. For each degree that a metal is cooled, therefore, the resistance decreases a certain definite percentage. This would indicate that at an extremely low temperature (near absolute zero) the resistance of a conductor would become extremely low, and this has proved to be the case. We shall discuss this aspect of conduction more fully later but here, it will be sufficient to state that at the temperature of liquid helium, certain metals become perfect conductors.

Resistance in solid conductors is due to the fact that the electrons must travel gaps between atomic systems. Within the sphere of influence of an atom the

[1] Part V, July 15 issue, page 778.

electron is believed to move freely. According to this theory, when the atoms no longer dash to and fro they may be so close that an electron passes from one to the next without essentially crossing any gap.

So far, our theory of electric conduction in metals has served us well but now, how shall we explain the fact that certain substances, usually relatively poor conductors, decrease in resistance with an increase in temperature? Carbon is such a substance. When the old style carbon filament lamp was cold, its resistance was high but shortly after the current was turned on, and the filament heated to incandescence, the resistance fell to a low value.

### Effect of Crystal Structure

In this case, probably, the arrangement of atoms or molecules in the material is such that the atoms are not permitted normally to approach each other closer than a certain distance. This may be due to the peculiar geometrical arrangement of the atoms which in turn is the result of the configuration of electrons in the atom. While it is unreasonable to talk of the shape of an atom, it is reasonable to suppose that, because of the configuration of the electrons, the atoms would behave like solid objects of definite geometrical shape.

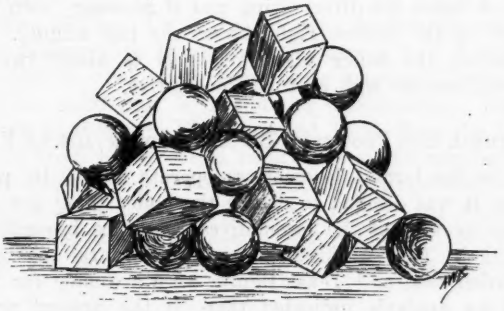

FIG. 4. A SIMILAR CONDITION PREVAILS IF THE OBJECTS ARE OF MIXED SHAPE, SOME SPHERICAL AND SOME CUBICAL

Suppose we consider a box full of small cubes—cubes of sugar, for instance. If care is taken, these cubes can easily be piled in rows so as completely to fill the space in the box. If the sugar was in the form of small spheres instead of cubes, however, they could not be made to fill all the space in the box. A similar condition would prevail if the lumps of sugar were of mixed shape—some spherical, some cubical, some other shapes. It is also apparent that while, in the case of the cubes, all surfaces of all cubes would be in actual contact, in the case of spheres only a small portion of the total area of the spheres would be in actual contact.

Now a similar condition prevails in the atomic structure of crystals. By means of x-rays, as will be discussed in later articles, scientists have been able to determine the geometrical arrangement of the atoms in various materials. Of course, since atoms are not solid bodies but merely systems of electrons and protons, there can be no such thing as "contact" between atoms as there is between cubes of sugar. The forces (repelling and attracting) in the atom are such, however, that the atoms are compelled to take certain positions with respect to each other. Thus, in the case of a sodium chloride crystal, the atoms of sodium and chlorine are arranged in a simple "cubic" fashion. The black balls represent the sodium atoms, the light ones the chlorine atoms.

### Explanation of Negative Temperature Coefficient

This brief discussion of crystal structure will enable us better to understand why such substances as carbon decrease in electrical resistance as the temperature increases. At normal temperature, the arrangement of the atoms in these substances is such that they are relatively far apart and the forces holding the electrons are

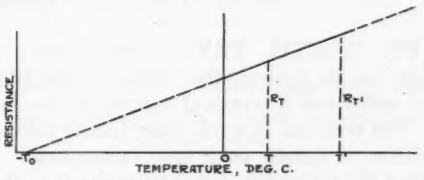


FIG. 5. CURVE SHOWING THE VARIATION OF RESISTANCE WITH TEMPERATURE

The relation of resistance of conductors to temperature is substantially linear, as shown. If this linear relation were maintained for all points of the temperature scale, at $T_0$ the resistance would be zero. At extremely low temperatures, this linear relation does not hold, however.

sufficiently great so that no ordinary electric field will remove them. Only occasionally will an electron belonging to one atom come close to the sphere of influence of another atom and then under the action of an external electric field, this electron may be passed from its own atom to the next. Naturally, at ordinary temperatures such materials are poor conductors.

As the temperature is increased, however, the molecular agitation among the atoms becomes more violent so that the collisions become more frequent. Also, because of the increased kinetic energy, the electrons are not held to the atom as tightly as before and they are loosened more easily. Thus, the conductivity of the material increases. The higher the temperature, the more violent and frequent the collisions and the more often is an electron passed from one atom to another—a hand to hand exchange. In the jargon of everyday electrical engineering, such substances are said to have a negative temperature coefficient.

### Two Main Factors Control Resistance Characteristics

From the foregoing, it must be apparent that two main factors control the resistance characteristics of solid conductors, first, the geometrical arrangement of the atoms and the distance between them; second, the degree of tightness with which the electrons are held to the atom. The latter varies with different atoms as we have seen.[2]

To free an electron from an atom requires a certain definite amount of energy, depending upon the stability characteristics of the atom. In some cases, a potential gradient of a few volts is sufficient, in others, a considerably greater potential is necessary. With a given spacing and arrangement of atoms, the resistance of the substance is dependent upon the amount of energy required to free the electrons. The atomic arrangement,

[2] Part IV, page 726, July 1 issue.

however, is quite as important a factor and it is only when the two factors are considered together that a satisfactory theory of solid conduction can be constructed.

Any conductor is heated by an electric current. As electrons under the action of an electric field are carried along, the energy of the field is imparted to the electrons as kinetic energy. As these electrons collide with the atoms and other electrons, this energy manifests itself in a general increase in the molecular agitation of the body. This we know and recognize as heat.

As the conductor heats, the resistance is either increased or decreased, depending upon whether the temprature coefficient is positive or negative. The energy for producing this heating effect is obtained from the energy stored in the electric field.

# Modern Boiler Plant for Railway Service

HIGH-PRESSURE DIRECT-STEAMING PLANT OF TEXAS & PACIFIC RAILWAY AT FT. WORTH USES HIGHEST OPERATING PRESSURE FOR THIS SERVICE

AT FT. WORTH, TEXAS, the largest division point on its system, the Texas & Pacific Railway has just completed a terminal known as the Lancaster Yards. The terminal is 4 mi. long, has 60 mi. of tracks and facilities to handle over 3000 cars a day. A hump is provided for switching cars by gravity into the classification yards, the speed and direction of the cars being governed by electrically operated car retarders and switch machines controlled by the tower men.

One of the most interesting features of the yards is the boiler room, one of the finest and most modern in the railway service and designed primarily to provide steam for direct steaming of locomotives in the roundhouse. This is the second direct steaming plant on the T. & P. system, the sixth in the country and the only one operating at a pressure in excess of 200 lb. In addition, steam is supplied to drive two air compressors, for testing purposes in the locomotive erection shop, for heating of water and heating some of the buildings.

Direct steaming of locomotives has a number of advantages besides the obvious one of smoke prevention. With this system fires are not started in the firebox until after the locomotive leaves the roundhouse. Steam at from 15 to 20 lb. pressure is first admitted to the empty boiler to warm it uniformly and avoid temperature stresses. After this, the boiler is filled with hot feedwater to the proper level in the gage glass and the pressure brought up to the full value of 200 to 250 lb. by means of a line from the boiler room.

At the same time the locomotive is steamed up, the oil is heated and the engine goes out of the roundhouse under its own power, with hot oil and clean flues, capable of developing full power, speed and efficiency from the time it picks up the load. An engine can be warmed up ready for the road in 14 minutes as against 3 to 4 hours for direct firing and if necessary men can work in the firebox right up to the last minute. In addition, the boiler plant efficiency is about two or three times as high as for a locomotive.

## NATURAL GAS PROVED TO BE MOST ADVANTAGEOUS FUEL

As the largest locomotives operate at 250 lb. pressure, it was decided to design the boiler plant for this pressure so that the locomotives would be brought up to their full working pressure. Natural gas, oil, Thurber coal and Texas lignite were available for fuel but an analysis indicated that, at the present price,

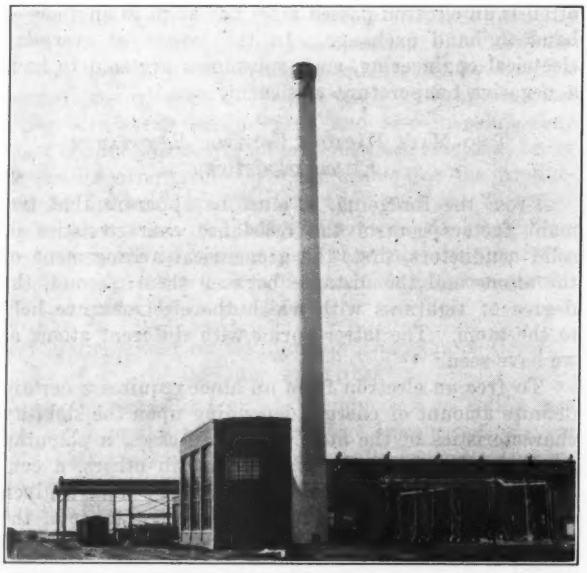

FIG. 1. EXTERIOR OF THE BOILER PLANT AT LANCASTER YARDS

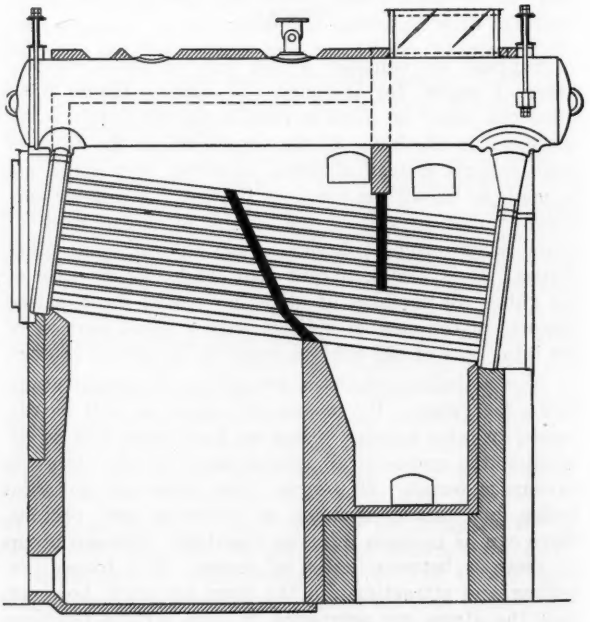

FIG. 2. CROSS SECTION OF THE BOILER AND FURNACE

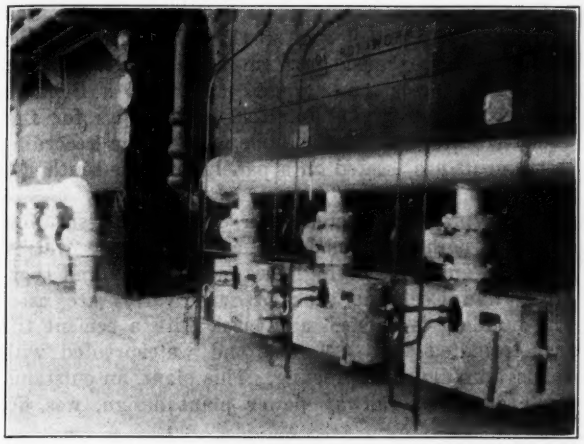

FIG. 3. TWO 511-HP. BOILERS ARE INSTALLED AND THE THIRD IS UNDER CONSTRUCTION

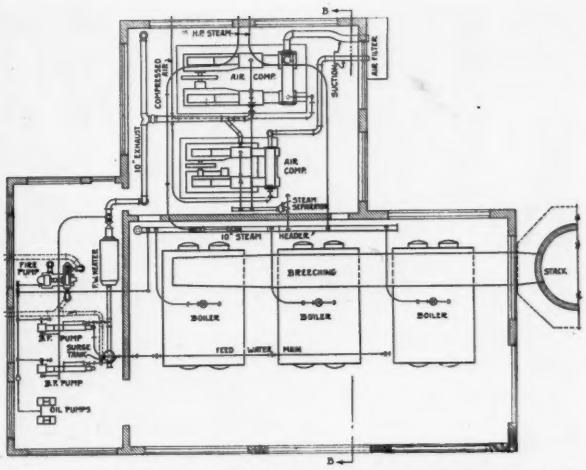


FIG. 4. PLAN OF THE BOILER ROOM, ENGINE ROOM AND PUMP ROOM

natural gas with fuel oil as standby was the most economical. Based on the 5-yr. sliding scale contract, it is estimated that the gas cost will average $0.177 per thousand cubic feet. Boiler and furnace design is such, however, that either stokers or pulverized coal can be used if fuel prices change sufficiently to make this desirable.

Two 511-hp., Union Iron Works, horizontal, water-tube boilers with Duquesne gas burners and designed for 250 lb. working pressure were originally installed and the third unit is now under construction. These boilers, as shown in Fig. 2, are set 12 ft. from the floor to the front header so as to provide ample combustion space and the foundation, carried 12 ft. below the firing floor level, is arranged to accommodate ash hoppers and ash handling equipment. Provision has also been made for the future installation of an overhead coal bunker with a travelling weight larry to deliver the coal either to stoker hoppers or unit pulverizers. Pressed red brick was used for the setting with the combustion chambers lined with 13 in. of Laclede-Christie fire brick. All three boilers are served by a Rust reënforced concrete chimney 175 ft. high and 96 in. diameter at the top.

### Steam Considered Best Drive for Compressors

Compressed air demands were estimated at approximately 1200 c.f.m. during the day shift and 600 c.f.m. during the night shift so that two, Worthington uniflow, steam driven, two-stage, 110-lb. compressors were installed, one 12½ and 23½ by 14 by 18-in. with a displacement of 1600 c.f.m. and the other 9½ and 16 by 9½ by 18-in. with a displacement of 700 c.f.m. Suction for the compressors is taken through Midwest air filters. Natural gas engine drive and synchronous motor drive with purchased power were also considered for this service and although the comparative figures showed natural gas engines to be the most economical, the use of steam was decided upon as better adapted to this particular service.

Two 14 by 8 by 12-in. Worthington simplex, steam

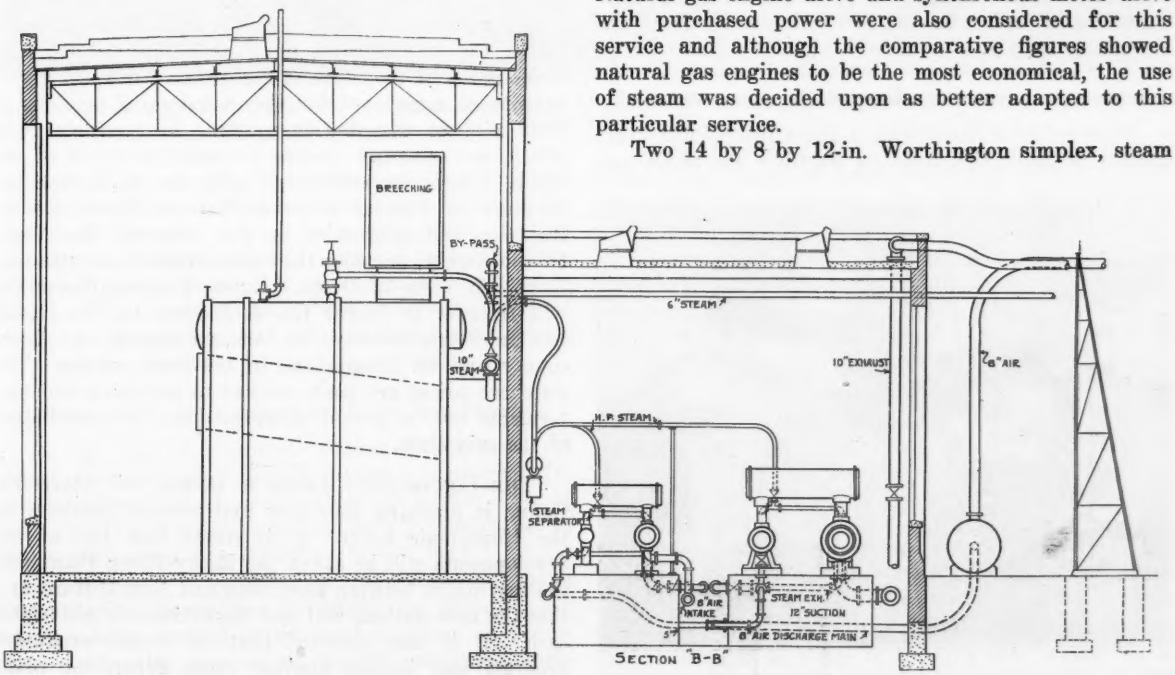


FIG. 5. CROSS SECTION OF THE PLANT SHOWING THE ARRANGEMENT OF STEAM LINES

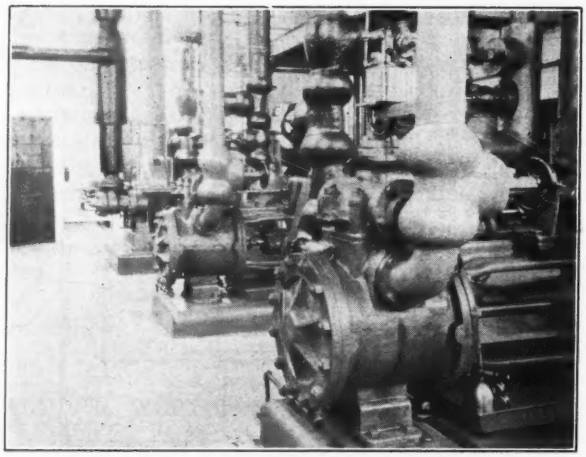

FIG. 6. BOILER FEED PUMPS ARE SIMPLEX DIRECT ACTING AND THE FIRE PUMP IS A TURBINE-DRIVEN CENTRIFUGAL

driven, pot valve, boiler feed pumps with a total capacity of 2000 b.hp. are installed. The pumps are controlled by Fisher excess pressure governors set for a pressure differential of 15 lb. The boilers are equipped with S-C regulators. Boiler feed pumps and the 1000-g.p.m. Dayton-Dowd centrifugal underwriter's fire pump driven by a Moore 125-hp., 2200-r.p.m., 250-lb. steam turbine are shown in Fig. 6. The A. M. Lockett & Co. fuel oil heater and pump unit for emergency service are also located in this room.

Feedwater is either heated in the 2500-hp. Worthington open feedwater heater or taken from the locomotive feedwater supply tank for the roundhouse. Compressors and auxiliaries are piped so that they exhaust to the feedwater heater in the boiler room or to the locomotive feedwater tank and in regular operating it has been found advisable to bypass the regular feedwater heater and take the boiler feedwater from the locomotive supply.

### Complete Instrument Layout Records Operation

Each boiler is fitted with a Hays two-pointer draft gage, a Republic $CO_2$ meter, a Republic gas meter and a Republic steam meter, while a three-point Republic pyrometer with one element at the outlet of each boiler measures the exhaust gas temperature. In addition there is a Wescott master gas meter and a Republic feedwater meter giving totalized flow of gas for fuel and feedwater to all the boilers. All the recording instruments are located on a panel along the south side of the pump room.

All piping is covered with Carey magnesia pipe covering painted identifying colors. Crane valves, National Tube Co. piping, Swartwout traps and separators and Cochrane back pressure valves are used. The building is of steel and brick with a cement tile roof insulated with Cel-o-tex and waterproofed with Johns-Manville waterproofing. This plant, an outstanding example of railway power plant design, was designed and built by the Austin Co. working with E. S. Pennabaker and P. E. Roll, principal assistant chief engineer and mechanical engineer respectively of the Texas & Pacific Railway. W. M. McClure is chief engineer of the plant.

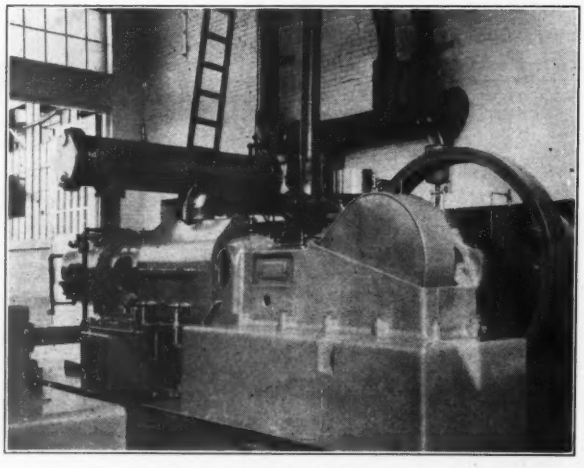

FIG. 7. TWO UNIFLOW-DRIVEN COMPRESSORS SUPPLY COMPRESSED AIR FOR THE SHOPS

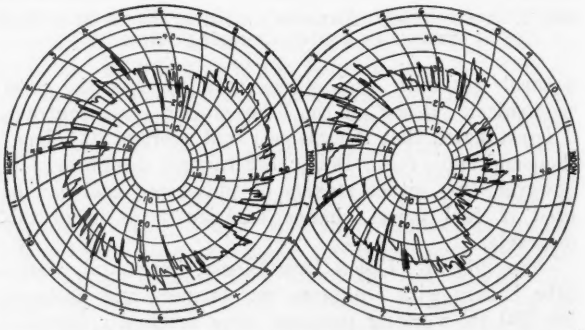

FIG. 8. FLOW METER CHARTS SHOW THE FLUCTUATING LOAD. CHARTS ARE MARKED IN THOUSANDS OF POUNDS OF STEAM PER HOUR

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Pacific Gas & Electric Co. and Great Western Power Co. of California have applied to the Railroad Commission of the State of California for authority to execute an agreement for the exchange of portions of their electric distribution systems in territory from which one company desires to retire in favor of the other. Under the contract, Pacific Gas & Electric Co. proposes to transfer to Great Western Power Co. its facilities and properties in the town of Rio Vista, Solano county, and also the transmission line extending from Rio Vista to Dixon. Great Western Power Co. will transfer to Pacific Gas & Electric Co. its Hindu line in Solano county, its Peters extension in Placer county and its Loomis line in the same county. The purchase prices are made subject to additions and betterments over a period of years since the installation of the said lines.

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The Connecticut Light & Power Co., Hartford, Conn., is planning four new hydroelectric projects on the Housatonic River. It is stated that two of the developments will be above the Rocky River Plant and the two others between Stevenson and New Milford and that the new stations will cost approximately $3,000,000 each. It is also reported that the entire expansion program may include another steam generating plant similar to the one at Devon.

# Power Plants Need Adequate Equipment of Tools

TYPE AND SIZE OF PLANT, TOGETHER WITH ITS RELATION TO INDUSTRY AND OUTSIDE SHOPS, DETERMINE TOOLS NEEDED. SEVERAL TYPES OF POWER AND HAND TOOLS ARE DESCRIBED

TOOLS FOR THE power plant must be carefully chosen to fit the type and size of the plant, its relation to its surroundings and, in consequence, the type and amount of repair and maintenance work that is to be carried on. Naturally, if the power plant is located in a district where there are good machine shops, well equipped to do its work at reasonable cost, it does not always need elaborate repair equipment. Yet the specialization and quantity production work in which most machine shops are engaged nowadays often makes it impossible for them to do work for power plants. As this work covers a wide field, it is becoming more and more necessary for the engineer to depend on his own organization. This is easier than it used to be, since much of the old back-breaking hand labor of power plant repair work can be eliminated by modern devices.

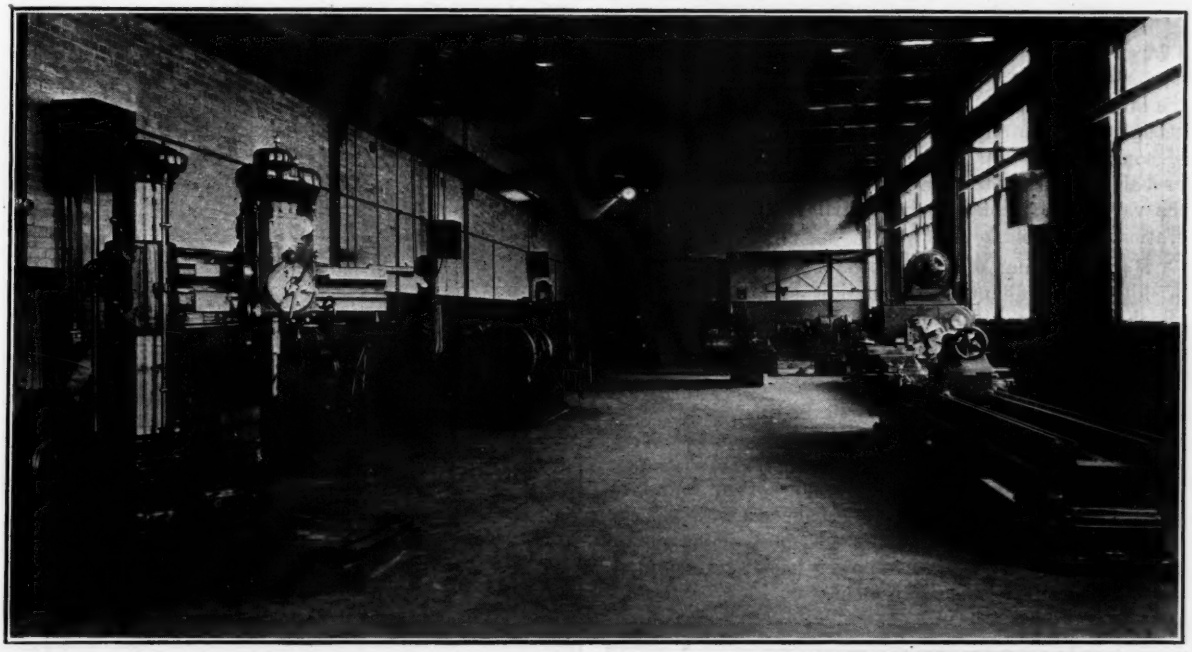


FIG. 1. THIS MACHINE SHOP, IN A LARGE CENTRAL STATION, CONTAINS POWER TOOLS FOR HANDLING WIDE VARIETY OF WORK

### TYPE OF PLANT DETERMINES SHOP EQUIPMENT

In the case of a central station, either steam or Diesel, some sort of a shop is almost a necessity. Increasing size of units, accompanied by higher costs of transportation of parts to the factory for repairs, not to mention the delay, are important factors here.

In the industrial power plant, conditions vary much more widely. Sometimes the industrial processes demand a large, well-equipped machine shop, carpenter shop, sheet metal shop and so on, with competent workmen. In such a case, the chief engineer of the plant may have the power plant under his jurisdiction and repairs for it may be handled as a departmental item, with help from outside on big jobs of new construction involving concrete work, pile-driving and the like.

### INDUSTRIAL AND BUILDING REQUIREMENTS

On the other hand, the industrial power plant may be connected with a highly specialized industry using only one type of equipment, such as a spinning mill, and a wide variety of industrial repair work and maintenance is not demanded. For such a case, the power plant may need some tools of its own.

Then there is the heating plant, either central or industrial, where the equipment is not so bulky, except for the boilers, and where heavy shop equipment is not needed but where smaller hand appliances are convenient. There are the special conditions of the office building plant, the institutional plant, the municipal pumping or heating plant, the hydroelectric plant, the Diesel engine plant. It is obvious that some care is necessary in selecting tools to fill all these conditions.

To show a few of the tools available for such cases as the foregoing, the following discussion has been prepared. To discuss many of the usual hand tools and elementary equipment with which every engineer must be familiar would be only to repeat much published material. Then, too, the ingenuity of the engineer must be exercised at all times in working out "kinks" to fit his particular conditions.

Figure 1 shows a modern machine shop installed in

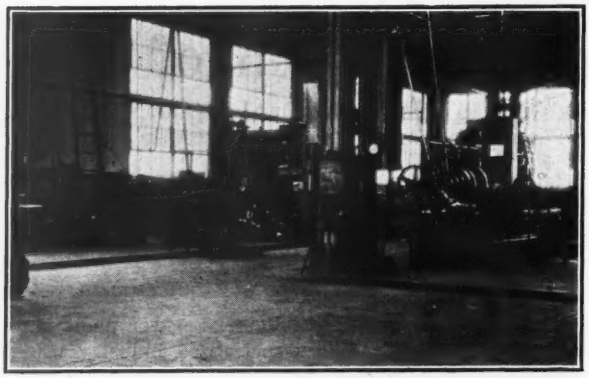


FIG. 2. THIS SHOP SERVES A LARGE DIESEL ENGINE PLANT

a large central station in the south. As will be noted, it contains a large engine lathe for swinging parts of the large turbines and pumps and a smaller lathe in the background. In any power plant machine shop a lathe of some kind, large or small, to fit the equipment, is probably the most flexible piece of equipment, owing to the variety of boring, turning, grinding and other operations it can perform.

Manufacturing of metal products involves the use of high-speed quantity production special machinery which is seldom applicable to power plant work. A turret lathe, however, might be of use in a large repair department for making check valves, special bolts, valve stems and the like.

### Millers, Drills and Accessories

Shapers and milling machines are often found in plants such as that shown in Fig. 1 where a wide variety of work is to be done. Radial drills, post drills, one or two grinders and possibly a power hack saw complete the main machine tool equipment.

FIG. 3. MAKING A REPAIR BY ELECTRIC WELDING

In Fig. 2 is shown the machine shop of a large Diesel engine plant. Here an engine lathe, grinder, drill and a precision lathe form the basis of equipment.

It is obvious that some sort of crane, air hoist or other form of handling equipment should be provided for the shop but discussion of this equipment is beyond the scope of this article.

In larger industrial plant shops, a hydraulic press of adequate capacity may often prove a great time and labor saver together with a power shear and possibly a bolt-making machine.

### Blacksmith's Equipment

Most shops contain some sort of blacksmith's equipment and few industrial power plants can get along without something of this sort. The usual anvil, forge,

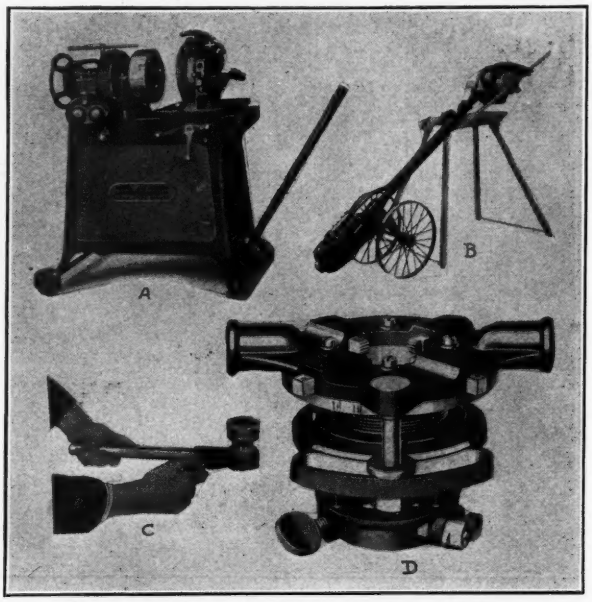



FIG. 4. SEVERAL CONVENIENT PIPE TOOLS

A—Portable pipe threading and cutting machine. B—Power drive, designed to drive from light socket and be easily portable. drives pipe for threading or cutting. C—Hand-operated ratchet pipe threading tool. D—Adjustable die for several pipe sizes

sledges, rasps, tongs and accessories for hand work are often provided. A convenient apparatus for the blacksmith that has been widely used is the power hammer shown in Fig. 5E. No helper is required for the smith who has personal control over all operations.

### Welding Finds Many Applications

With the introduction of autogenous and electric welding in recent years, great changes have taken place in repair methods used in the power plant. Many repairs and much new construction are done by welding, in a short time and at low cost, that would otherwise mean a great deal of machine work. Of course, some care is necessary and certain types of work are still subjects of considerable controversy. But on the whole, the opinion of engineers is that welding is here to stay.

Electric welding of two small pieces is illustrated in Fig. 3; Fig. 5-B shows a cutting torch developed to use

natural or illuminating gas; Fig. 5-C shows a cutting torch for use with acetylene.

If the plant has much sheet metal work to do, a set of rolls and a power shear will be found worth while. In addition to this a hand-operated, motor-driven shear, Fig. 5-D, has been developed to shear sheet iron up to 18 U. S. gage and other sheet materials as well. This is designed to shear a minimum radius of 1 in. and to operate from a 110-v. circuit.

### Sometimes There Is Work for the Carpenter

There is still considerable carpenter work to be done about industrial plants and if the power engineer is also the industrial plant engineer, he may need a carpenter shop, equipped possibly with a jointer or planer, circular saws and even a band saw. A woodworking machine, Fig. 5-F, has been developed that will perform many of the usual operations. As can be seen, it consists of a motor suspended so it can be turned at any angle and arranged so that saws, routing tools and other equipment can be mounted directly on the motor shaft. This machine is designed to be used for the usual cross-cutting and ripping, also for beveling, routing, tenoning, sanding and so on.

For general use around an industrial plant, several power-driven hand saws have been developed. Figure 5-A shows one of these in use. This unit is driven by compressed air although others are supplied with electric motor drive.

If large surfaces are to be painted, this is usually done with the paint spray nowadays, instead of with the brush, although the latter is often used for smaller work.

### Pipe Tools Speed Up Work on Important Items

Piping is one of the most important power plant and industrial items and no power plant machine shop can afford to neglect it. Figure 1 shows a large pipe-threading and cutting machine. Portable machines that can be taken right to the job are also popular for many classes of work. Pipe-bending machines are commonly used on pipe and conduit today, instead of the old-fashioned "hickey." Figure 4-A shows one form of portable pipe-threading machine. Figure 4-B shows a power drive designed to be taken to the work; it turns the pipe by means of a chuck while the threading or cutting tool is held stationary, as shown. Of course, the hand ratchet die, Fig. 4-C, finds many applications. Figure 4-B shows an adjustable die in which the cutters are arranged to take different sized pipe without removing them from the holder. Many engineers have reported great success in repairing pipe by welding; also we now find power plants in which high-pressure main steam piping is fabricated entirely in this way.

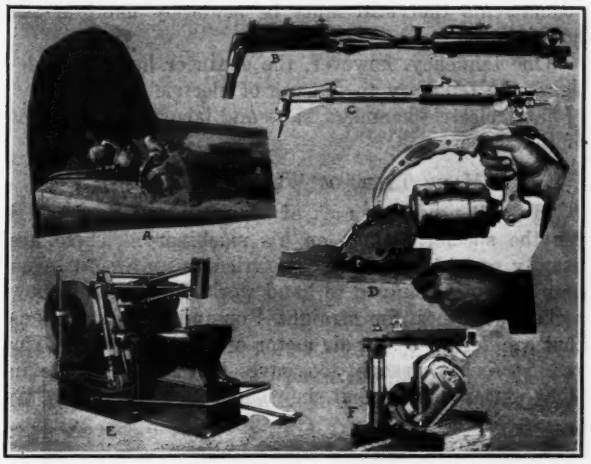



FIG. 5. GROUP OF TOOLS DESIGNED TO SPEED UP REPAIR OPERATIONS

A—Air-driven, portable circular saw. B—Cutting torch for use with gas. C—Cutting torch for use with acetylene. D—Motor-operated hand shear for cutting sheet metal. E—Blacksmith's hammer eliminates need of striker. F—This woodworking machine is designed to perform many operations

### Hand Tools Still Have Important Function

Most power plants will have the usual hand pipe cutters, taps, dies, Stillson wrenches, special wrenches for brass pipe and so on and these are so much a part of the engineer's elementary education that discussion of them is superfluous. The same is true of the usual hand tools such as files, chisels, hammers, measuring instruments and so on. These still have their legitimate function and there are certain types of repairs and

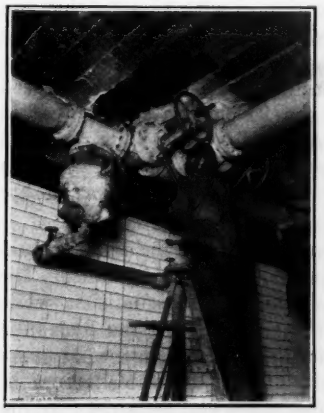


FIG. 6. RATCHET SOCKET WRENCH ENABLES NUTS ON VALVE TO BE SET UP WHERE ROOM IS SCARCE.

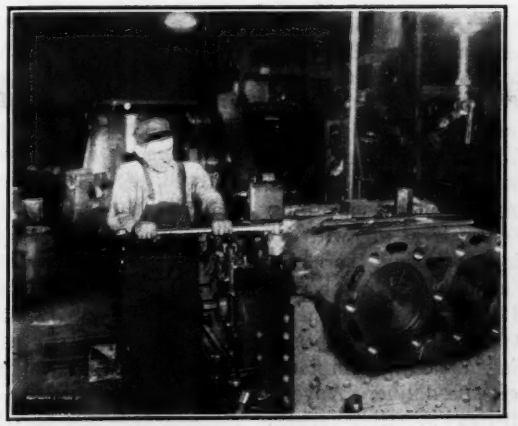


FIG. 7. SHOWING USE OF A LARGE SOCKET WRENCH WITH SLIDING BAR. WHEN WORKING IN CLOSE QUARTERS, THIS PERMITS SOCKET TO BE KEPT ON NUT AT ALL TIMES.

FIG. 8. TIGHTENING NUTS AND BOLTS WITH SOCKET WRENCHES ON A LARGE PUMPING ENGINE

adjustments that still must be made by hand in the power house.

One tendency, however, the engineer hails with delight: the tendency to the use of electric drills instead of hand, electric hammers, saws and labor-saving devices of that type.

### Many Types of Wrenches Needed

He still needs his rack of spanners and S-wrenches for the special fittings on his machinery. These are usually provided to fit each particular unit. But even here he is not confined to hand work, for there are now socket wrenches for straight "on-and-off" operations that are driven by an air motor or electric motor. The ratchet socket wrench, too, saves him much trouble in tight places such as that shown in Fig. 6.

Besides this, when working in such a location, the additional grip of the socket wrench tends to promote safety, as the operator can get a good pull without slipping. On a job requiring a strong pull, as in Fig. 7, a sliding rod can be used to speed up the work in a limited space. Figure 8 shows engineers using socket wrenches in tightening up bolts on a pumping engine, a set of the sockets and their handle being shown in the foreground.

Discussion of repairs to electrical equipment, especially wiring, are beyond the scope of this article. Special tools for the electrical repair man are required, although repair and maintenance of frames, foundations, bearings and so on are handled by the usual mechanical equipment.

# Propeller Type Turbine Proves Its Worth

Data on Mechanical and Hydraulic Balance, Speed Regulation, Useful Life and Other Factors Show that These Units Are Here to Stay. By H. S. Schreiner

DEVELOPMENT of the propeller type hydraulic turbine has reached a point at which we can look back only a short time and analyze various experiences and opinions that have been crystallizing in our minds. The propeller type turbine has come to stay, although it is certain that one will see modifications of design, novel and more modern constructions and more definite demarcations as to its proper field for this new and useful equipment.

Undoubtedly some will object to the use of the word "new" as applied to this type of turbine. It is true that, as to general shape, the propeller type of rotor is extremely old, considerably beyond the memory of living men. It is also true that the patent archives of the more progressive nations are plentifully supplied with Letters Patent granted to inventors, in which the so-called propeller type turbine forms an essential part. But it is also true that the propeller type of hydraulic turbine as we know it today is of recent origin, which cannot be established much before 1912.

### Origin of the Propeller Type Runner

Without doubt it was Dr. Ing. Kaplan, then in Austria, who began and carried on energetically the development of the propeller rotor of high specific speed for low-head water turbines. The type of turbine developed by Kaplan differed essentially from all its predecessors in that it was fed through a radially-disposed set of gates, so that such a turbine could be governed by modern oil pressure governors, something that could be done only imperfectly, if at all, with its predecessors. The radial, outside gate casing, therefore, is one of the features that has contributed to the success of this type of turbine and led to its very general adoption, something that cannot be said of its forbears. It is easy to trace the outward visible marks of Kaplan's mental tendencies along the high speed line. Anyone familiar with his many writings in the various European magazines and his interesting book will have no reasonable doubts in stating that Kaplan was the leading spirit in this line of progress.

Having established the family tree, let us now pass to the practical use of the high specific speed low head water turbine, restricting ourselves to the work done in this country and Canada. The first propeller type turbine with a radial gate casing was installed about 1916 in Michigan. Since then, other inventors have applied for patents and we find today some six different builders manufacturing propeller turbines of various types, all with the outside radial type of gate casing. As to the turbine rotors themselves, we may broadly distinguish between the narrow and wide vanes and subdivide these two again into two others: first, the comparatively flat profile with vanes coming out practically at right angles to the axis of rotation and second, the type with vanes issuing diagonally with respect to the axis of rotation.

### Mechanical and Hydraulic Balance and Speed Variations

Number of vanes varies from three to six. In the four-vane type, we have seen the overthrow of an old-time rule whereby the number of gates was not to be a simple multiple of the number of turbine vanes, for there are many four-vane runners with 16 gates that run along as quietly as any low specific speed turbine. The fact that the vanes are so far away from the gate tips undoubtedly accounts for this; even in the lower speed Francis types, down to say 25 specific speed, we find operating conditions as to quieter running improved, as a result of increased clearances between the gate tips and the runner vanes. Differences in operation are found with varying numbers of vanes.

Two conditions of balance must be considered: actual running mechanical balance and hydraulic balance. The first is the result of a mere mechanical condition, while the second arises from the similarity of the hydraulic passages around the wheel. It seems somewhat more difficult to divide the slight and inevitable errors of manufacture over only three vanes and get quiet running and concentric wear on the bearings than to do so with four, five or six vanes. Accurate foundry work reduces the hydraulic dissimilarity to a negligible quantity. It

is evident that as rotational speeds increase, dynamic balancing will be correspondingly demanded.

As specific speeds increase from about 50 upwards, we find a slightly increasing tendency to unsteadiness even on fixed gate operation and hand regulation. At a specific speed of about 80, we find variations from a quarter cycle to a half cycle with no apparent reason for the fluctuation. With moderately wide vanes, at specific speeds of 130 to 150 we find from one and a half to two cycles variation, while with the extremely narrow types we find much more, the variation in some cases approaching a regular, periodic voltage surge. On the other hand, when the vanes are long and have much overlap, another phenomenon arises, which apparently is a hydraulic choking effect and introduces sharp S turns into the power-speed curves. The same effect has been observed with concentric draft tubes having disproportionately large frictional surfaces.

Draft tubes having marked irregularities in the velocity curve tend to set up periodic pressure variations and to accentuate the foregoing frequency variations. In one case, a choked draft tube discharge caused disagreeable voltage surges that were greatly reduced when the tail race was excavated somewhat deeper and the water had more chance to get away with less restraint. The draft tube in that particular case was a straight conical tube about two diameters long, taking the diameter of the runner as unity.

### Synchronizing of Propeller Turbines

Propeller turbines do not synchronize as well and easily as do turbines of lower specific speed. In this regard, it has been observed by those concerned with the practical operation of such units, that turbines having markedly less vane area in proportion to the area of the full runner diameter are more flighty and difficult to synchronize than those with relatively large vane area. Facility of synchronizing is improved as the percentage of vane area increases, up to the point where the before mentioned hydraulic choking effect starts, where one finds pressure variations of the necessarily short draft tubes transmitted into the runner itself; the sum total of these effects is a minimum in the propeller type of moderate area, or something between the two extremes of vane areas of the narrow and the extremely wide.

Utility companies are much interested in the useful life of the runners of such turbines. Given three correctly designed runners—one of each of the three types as regards vane area: the narrow blade, the moderate area blade and the wide blade—we can say that the flow through the runner is more irregular and difficult to control harmoniously in the narrow blade types and therefore subject to greater angular variation of flow from full load down to say half load. It has been concluded, naturally, that, all other conditions being equal, such runners will be inherently more liable to pitting and erosion. Naturally the narrow blade runners are structurally weaker for given size and material. If, however, such narrow vane runners are always operated at one gate setting, that of best efficiency, the tendency to pitting will be greatly reduced.

Periodic inspection and welding of pitted places before they get beyond repair will prolong the useful life of any runner. At the other extreme, the wide blade, we find far greater mechanical strength but as the vane sections are comparatively straight and approach nearly parallel channel profiles there is the tendency for slight irregularities of surface to show up in erosion at the periphery of such runners where the straightness of the sections is most pronounced. For such reasons, the runner of moderate vane area is favored.

### Thrust May Reverse Under Large Load Changes

Another matter of some importance is the tendency for propeller runners to jump when there are large load changes of large amount and also when shutting down. This is caused by the reversal of thrust from downward to upward at about 0.4 gate opening. Suitable provision should be made in the design so that this jumping does not cause damage. Power plant men who have observed this matter are beginning to think that the turbine thrust bearings should have double load faces, one for the downward and one for the upward thrust.

At times of high tailwater, irregularities of frequency are likely to be more pronounced than at other times, especially when the tailwater is just at about the runner elevation. A number of theories have been advanced for this, but the practical man will find more satisfaction in tailwater regulation and in preventing the cause than in adding another gadget to correct for a condition that can be otherwise cured. Turbine governors are all but human, they already have so many accessories hitched to them that we may soon demand larger governors from the manufacturers, so that we will have more room to put on accessories.

Looking at another phase of operation, it is apparent to anyone who has studied propeller turbine efficiency curves that these units are suitable for operation only within a limited range of load, if one wishes to use the water economically. At best, the economical range is from 0.8 to full gate. That means that the conventional propeller turbine serves best when part of a system so that it can be set at one load and left there. But these statements should not be interpreted to mean that these turbines will not regulate commercially, for they certainly do regulate.

### Propeller Runners with Adjustable Blades

All of the foregoing has been said with respect to the propeller turbine with rigid vanes. As time goes on, we shall have more experience with the manually-adjustable vanes now being installed in certain plants, as soon as our operators get together and compare notes. In Europe, the automatically-adjustable vane propellers are said to be operating successfully, with their efficiency peak at about half load and extremely flat efficiency curve over the whole range. Undoubtedly we shall hear shortly of such installations in the United States, when we shall have plants containing five or six rigid-blade wheels accompanied by one or two automatically-adjustable vane wheels to do the regulating.

In summary, it may be affirmed, on the basis of our experience with rigid blade propeller turbines, that they are here to stay. No insurmountable difficulties have been encountered. Many predicted defects have not appeared and those which have appeared will be alleviated, if not wholly corrected, in time, as we obtain increased knowledge and more case histories. While we are watching the propeller turbine, let us also recall that we have not as yet entirely solved pitting and other

troubles with units having specific speeds only a fraction of those of the propeller turbine. Draft tubes have improved immensely with the introduction of speeds above 100 and the writer believes that future progress in propeller wheels will go hand in hand with draft tube improvement, especially as regards steadiness of operation and high tailwater conditions.

It must also be remembered that the propeller turbine is somewhat weaker structurally than the high-speed Francis turbine; proportionate care should be exercised, therefore, that logs do not get into the turbine casing because the cantilevered vanes act alone and do not have the deep and strengthening rim to bind them together at their free ends. Extra attention should also be given to the thrust bearings for propeller turbines, because they have a somewhat higher thrust than Francis turbines. It must also be borne in mind that the failure of the thrust bearing will, in nine cases out of ten, result in destruction of the runner and gates, as the propeller turbine runs in its casing with comparatively small clearances. If a bearing fails, the runner will deflect to one side and, on account of its high peripheral speed, will spiral up into the gate casing, breaking any gates it may strike. Of course, such accidents are not chargeable to the propeller turbine as such.

# Banner Creameries Co. Starts New Ice Plant

RAW WATER, STATIONARY CAN SYSTEM IS USED FOR NEW 50-T. PLANT. AMMONIA COMPRESSORS AND ELECTRIC GENERATORS ARE DRIVEN BY GAS ENGINES

ONE OF THE FINEST ice plants in the Southwest was put into service last May by the Banner Creameries Co. of Abilene, Texas. The plant, with an ice-making capacity of 50 t., uses the Arctic-Pownall stationary can, raw water system and two 10 by 10-in. York ammonia compressors are driven by two 185-hp., 277-r.p.m. Bruce-MacBeth gas engines.

As can be seen in Fig. 1, each engine has two driving pulleys, one on each end of the shaft. The compressor is belt-driven from one end and a 120-kw., 900 r.p.m., 240-v., 3-phase, 60-cycle General Electric generator with a 4-kw. exciter belted to the other end. These generators supply all the electric power needed in the plant for lights and auxiliaries and, in addition, supply power to operate all the equipment in the adjoining creamery. The creamery load includes two 6 by 6-in. York compressors, each belted to a Fairbanks-Morse 15-hp., 1150-r.p.m., 220-v. motor.

These two small machines take care of practically all the creamery load consisting of fruit and vanilla ice cream hardening rooms kept at—10 deg. F., two milk vaults kept at 40 deg. F., a butter vault kept at 32 deg. F., and a 60-qt. brine freezer for ice cream.

In addition to this load, a new 80-qt. direct expansion freezer is carried by the new ice plant. Originally the creamery was alone and the two 6 by 6-in. compressors were operated by purchased power. After the ice plant was built this spring, it was considered advisable to continue the operation of the two small machines, due to the arrangement of equipment, the range of temperatures necessary and, principally, because in summer the 10 by 10-in. machines are well loaded with the ice plant load. Steam for the pasteurizers, sterilizer and bottle washer is furnished by a low-pressure, gas-fired Murray Iron Works boiler.

The creamery handles 1100 gal. of milk a day and makes 300 gal. of ice cream which is distributed over a considerable territory, one truck route being over 200 mi. long. Much of it, however, is sold direct from the ice cream dock shown in the foreground in Fig. 2. This dock, on Sundays is served by seven men and as many as 1002 cars have been served in a single day. One of the interesting features of the plant is the display case of fancy ice cream forms used to show customers possible designs and color combinations. These are made from paraffine, colored or uncolored as the case may be.

## STATIONARY CANS ENABLE NEAT APPEARANCE OF TANK ROOM TO BE MAINTAINED

Ice is sold wholesale to the Independent Ice & Refrigeration Co., which retails it throughout the city as well as from a retail dock maintained at the plant and shown in Fig. 2 at the far end of the building.

Shown in Fig. 3, is a plan and section of the building and in Fig. 4 a view of the tank room. In this view can be seen the main expansion valve, the two ex-

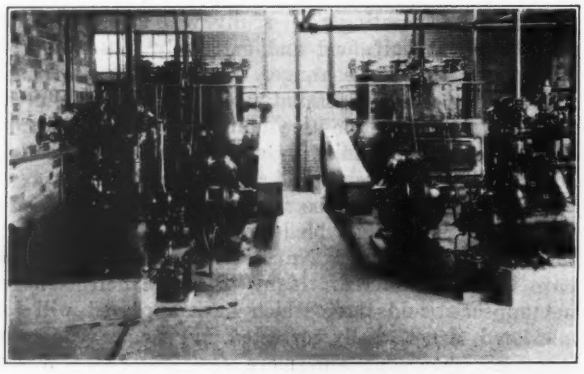


FIG. 1. NATURAL GAS ENGINES DRIVE THE TWO COMPRESSORS AND ELECTRIC GENERATORS

FIG. 2. CONDENSER WATER IS COOLED IN A SPRAY POND ON THE ROOF

pansion valves to the ice storage room, the brine agitator motor, the liquid ammonia gage and, at the far end of the room, the suction line to the compressors.

Ten tanks of 78 cans each are arranged five tanks on each side of the York brine cooler, giving a total of 780 300-lb. cans. In the Arctic-Pownall system, the cans are filled, cores drained and water agitated from the bottom of the cans by the arrangement shown in Fig. 5. Cans are automatically filled to a fixed level each time in such a way that it is impossible for the water to slop over and dilute the brine.

Air for agitation is furnished by an Allen & Billmyre Type T, 4-stage, 325-lb. pressure centrifugal compressor driven by a 5-hp., 3600-r.p.m., 220-v. Star motor. The Arctic brine agitator is driven by a 10-hp., 900-r.p.m., 220-v., Cleveland motor.

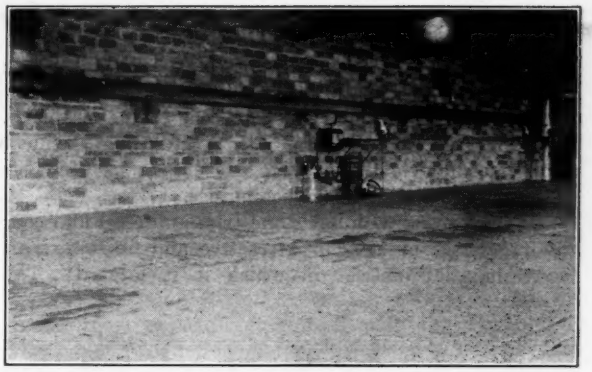


FIG. 4. TANKS ARE ARRANGED ON EACH SIDE OF A CENTRAL BRINE COOLER

### Ice Is Melted from Cans and Pulled by Hollow Rods Frozen in Cake

To make the plant capacity 14 to 16 deg. F., brine is circulated for about 48 hr. Two or three hours before the can is frozen, the brine circulation is stopped until freezing is complete by closing two quick acting valves between the brine cooler and the tank. This allows the brine to warm up slightly. After freezing is complete, the warm brine pump, a Weiman 5-in., single-stage, centrifugal, driven by a 5-hp., 720-r.p.m. Allis-Chalmers motor, is started and the brine circulated through the water storage tank until a temperature of 35 to 40 deg. F. is reached. This melts the ice from the sides of the can. The bottom of the can is then loosened by spraying with a jet of warm water. Warm water from the discharge of the condenser is used for this purpose, the water being supplied from the discharge of the cooling water pump so that an additional pumping unit for melting is not needed.

After loosening, the ice cakes are picked up three at a time by a 1-t. Shepard Liftabout hoist and carried to the dump. The cans are left in place and the ice lifted by hollow rods frozen in the cake. At the dump, these rods are melted out by warm water from special jet needles. As shown by Fig. 6, this water is supplied from a special heater around the discharge gas line of the compressor. From the dump, the ice slides down a chute to the 28 deg. F. storage room, where it is stored or put through the scoring machine.

For the condenser, a York shell and tube type with the ammonia gas introduced near the bottom, is used. The Arctic ammonia receiver is 20 ft. long and 15 in. in diameter, fitted with an Ashcroft safety valve. Cooling water is circulated by a 5-in., 600-g.p.m., 50-ft. head Allis-Chalmers centrifugal pump driven by a 15-hp., 220-v. motor. The spray pond located on the roof consists of six spray groups of five nozzles each.

### Water Is Chilled Before Cans Are Filled

Water for ice making is taken from the city mains and stored in an insulated storage and cooling tank. At the top of this tank are the warm brine coils and below these direct expansion coils which are used to

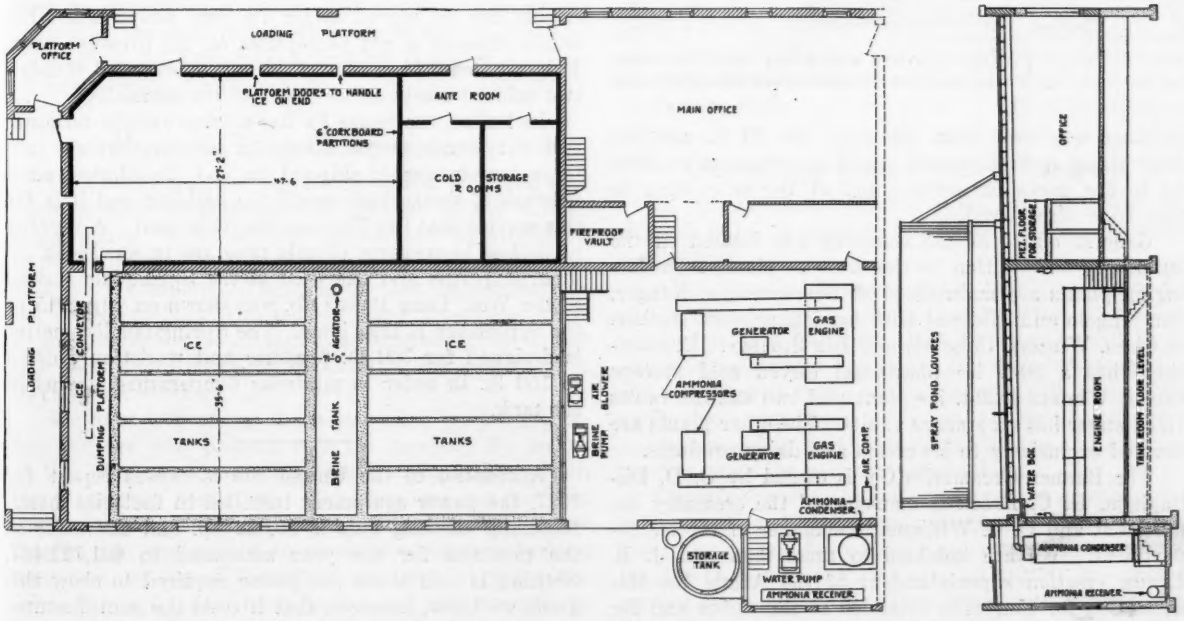



FIG. 3. PLAN AND SECTION OF THE ICE PLANT SHOWING THE MACHINERY ARRANGEMENT

bring the water temperature as low as possible before the cans are filled.

Natural gas for the engines is purchased from the Lone Star Gas Co. and brought from the company's Ft. Worth pipe line through a special line to the ice plant, a distance of about 2 mi. A Worthington vertical compressor, driven by a Novo gas engine, is used for supplying starting air for the engines.

Of dark brick with cut stone trim and steel and concrete roof, the building is attractive and fits well with the residential district in which it is located. The

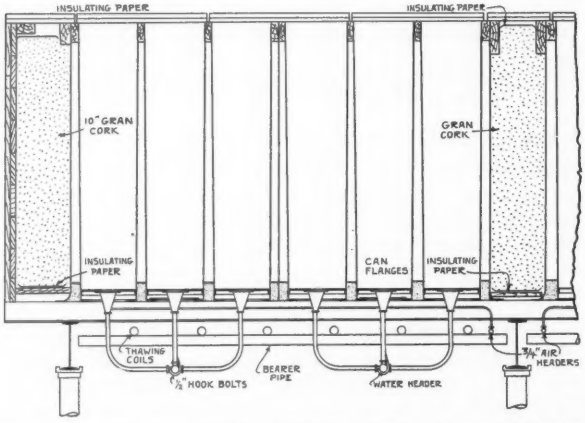



FIG. 5. ICE CANS ARE FILLED AND CORES DRAWN THROUGH THE BOTTOM WITH THE ARCTIC-POWNALL SYSTEM

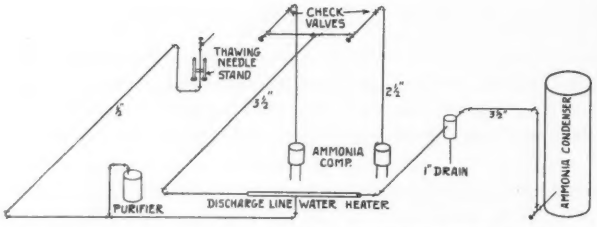



FIG. 6. MAIN PIPING LAYOUT SHOWING THE METHOD OF SUPPLYING WARM WATER TO THE MELTING NEEDLES

building sets back from the curb line 23 ft. and the intervening space is paved, enabling customers to drive up to the docks for service and at the same time be free from street traffic.

General offices of the company are located in the building. In addition to the Abilene plant, manufacturing plants are maintained at Breckenridge, Ranger, San Angelo and Midland with hardening room stations at Cisco, Winters, Colorado and Big Springs. Breckenridge has a 90-t. ice plant and eleven cold storage vaults, Winters a 20-t. ice plant and two storage vaults and Ranger has six storage vaults. The other plants are devoted exclusively to ice cream and dairy products.

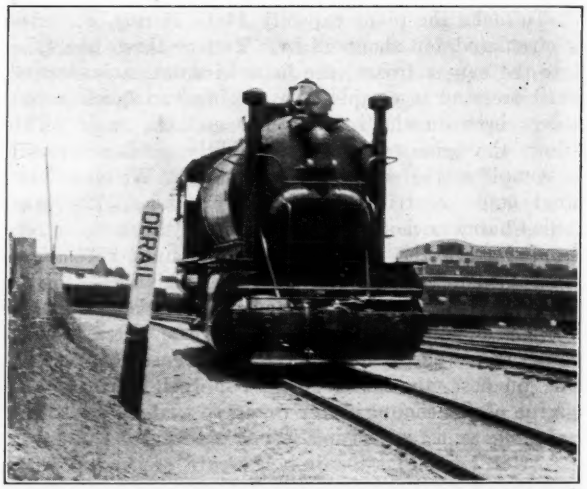
The Banner Creameries Co. is owned by O. D. Dillingham, G. C. Brock is manager of the creamery department and O. C. Williams is manager of the ice department. We are indebted to these men and J. R. Evans, erection superintendent of the Arctic Ice Machine Co., for courtesies extended to the editor and for information on which this article is based.

# Sante Fe Uses Fireless Engine

THERMOS BOTTLES are not usually associated with the serious business of railroading, yet the Sante Fe Railroad has purchased and is using a fireless locomotive called the "Thermos Bottle," for its Dallas freight terminal.

This locomotive, shown in the photograph, is 11 ft. 4 in. in length, has six drivers and no trucks, weighs 175,000 lb. and is rated to pull 1150 t. The boiler is made of 1½-in. boiler plate covered with 4 in. of lagging. In the morning, it is filled about ⅓ full of hot water and then charged with steam up to 200 lb. pressure.

Leaving the boiler, the steam passes through a reducing valve and is throttled to 60 lb. for use in the large diameter cylinders. The locomotive will work on as low as 5 lb. pressure; in fact, it is said that the




FRONT VIEW OF THE FIRELESS LOCOMOTIVE SHOWING THE TWO EXHAUST STACKS

engine can be moved under its own power when the boiler pressure is not perceptible on the pressure gage. Exhaust steam from the cylinders is discharged through two exhaust stacks at the front of the locomotive.

In Dallas, the Sante Fe has a large freight terminal and warehouses several stories in height. Freight into these warehouses is shipped in and distributed on a network of tracks underneath the building and it is for this service that the Thermos Bottle is used. A number of fireless locomotives of this type are in service in industrial plants and one used at the Springdale station of the West Penn Power Co. was shown on page 915 of the September 1, 1927 issue. The Springdale locomotive is designed for 300 lb. pressure and works only down to 150 lb. in order to minimize temperature strains in the tank.

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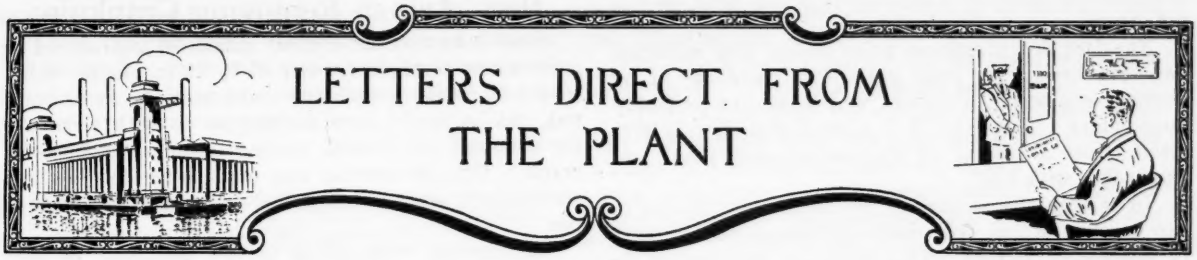
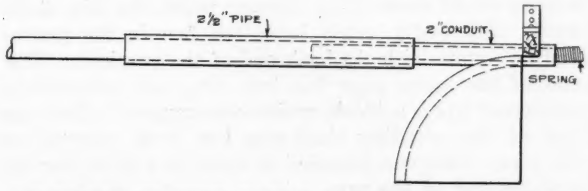
ACCORDING to the United States census report for 1927, the power equipment installed in factories manufacturing chewing gum is 10,022 hp. and the value of the products for the year amounted to $61,722,467. Nothing is said about the power required to chew this gum; we know, however, that it costs the manufacturer nothing.




## Spring Aids Bending of Electric Conduit

ALUMINUM conduits of standard iron pipe sizes, as used for electric cables, can be bent easily to any desired angle by inserting in them a close, coiled steel spring. For bending a 2-in. conduit to an inside radius of 9 in. a coil is wound on a 1⅜ in. diameter mandrel in the lathe, using steel spring wire $\frac{5}{32}$ in. diameter. When released, the coil will have a diameter of slightly less than 2 in. and can readily be slipped into a 2 in. conduit. The sketch shows the conduit and form ready




ELECTRIC CONDUIT EASILY BENT WHEN SPRING IS INSERTED

for bending. To assist the bending a 2½-in. iron pipe is slipped over the aluminum conduit.

When the bend is completed the coil can be removed readily by turning it in the right direction and at the same time pulling it, both operations tending to decrease the coil diameter. The form can be made of cast iron or hard wood and provided with a groove which may be formed in a lathe. The width of the groove should be the same as the diameter of the conduit and its depth a little more than half the diameter.

Long Beach, Calif. E. J. JORDAN.

## Power Plant Cooperation

IN A GREAT MANY power plants, it will be found that there is some friction between the men of the various departments. Most of this friction can be attributed to misunderstanding. As time goes on, it becomes more and more complex. The men in one department do not coöperate fully with men in other departments. It is not always the men's fault, as sometimes they do not have the opportunity to understand the problems of their fellow workers.

We have worked out a scheme which we are following and are well pleased with the results. By means of this plan, we are securing better coöperation within the plant than heretofore. The plan may not work in some plants but it is doing very well with us. A few months ago, we wanted to break in some new turbine operators, so one of the extra men was taken for the job. When he had been broken in well enough to handle things, he was left alone in the turbine room and the regular turbine operator was sent into the boiler room to acquaint himself with the workings of the steam production end of the plant. He was kept there until he had a fairly good knowledge of the routine of the boiler room work and saw clearly the problems which the boiler room operators are up against at times. He saw with his own eyes what happens when the turbine operator does not coöperate with the boiler room operator. He could therefore better realize the importance of coöperation between the turbine room and the boiler room, and after his experience, was more than ever willing to help in any way that he could.

Next we reversed the procedure so as to have the principal boiler room men, in turn, learn turbine operation and become familiar with the various machines, so that if called upon to do so, they could operate the turbine and auxiliaries. The boiler room men then began to realize what the problems of the turbine room men were and, by understanding them in this way, they were more than willing to coöperate fully.

Previous to the adoption of this plan, it seemed that everybody was for himself and that there was not the friendly spirit between the men of the various departments that there is today. We feel that this plan has resulted in several benefits. It has established a more friendly feeling between the men of the various departments; by understanding each other's problems, the men are working things out together with much more satisfaction and better results; it also makes for safer operation. Still further, when we become hard pushed for an operator in one of the departments, we shall have no difficulty in filling the place at once and always have a good reserve left.

Denver, Colo. F. R. RAWSON.

## Covering Hot Pipes with Foil

IN HIS LETTER on page 845 of the August 1 issue, Mr. Warner failed to mention several points that are worth considering.

Aluminum foil has none of the toughness of tin foil and is even harder to handle than lead foil. For a 4-in. pipe, a strip of foil more than 12 in. wide will be required as covering. Try to put this on a hot steam pipe and wrap it with twine. I imagine you will fail in doing much more than burn your hands. Small cold pipes can be covered by first varnishing the pipe and applying the foil while the varnish is still sticky.

There is one way the foil can be put on any size pipe, hot or cold, and that is to use the foil in rolls about 1½ in. wide and turn it in rings around the pipe like friction tape, allowing each ring to overlap the preceding one for about ¼ in. Then wrap with twine as Mr. Warner suggests, although it is difficult to wind very

thin asbestos string with any degree of tightness, as it is not strong.

The fact that aluminum paint lessens heat radiation has been known for some years and made use of by heating engineers, plumbers and even the ordinary householder. Therefore, it is a good idea first to give steam pipes a coating of aluminum-bronze paint and then cover with foil.

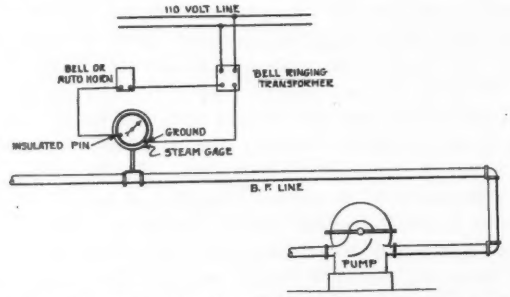
In mixing the aluminum powder, a good liquid to use consists of one part common varnish to six parts of benzine by volume. This should be well shaken together, a little of the powder being mixed with some of this liquid and used at once, as it hardens in a short time if left in an open dish.

In one part of his letter, Mr. Warner writes that the foil must be wound tightly over the asbestos string. It will be difficult to wind very thin foil tight over anything except a perfectly smooth surface.

Toronto, Canada. JOHN THORN.

## Simple Alarm Indicates When Pump Stops

AS A RULE, the only alarm that is given when a feed pump has stopped, is the low water alarm. By the time this has sounded there is little opportunity to see what is the trouble with the pump or use some other feeding device.




OLD PRESSURE GAGE SERVES AS MECHANISM FOR ALARM TO INDICATE STOPPAGE OF FEED PUMP

To overcome this difficulty, I have made and installed a simple device which gives an alarm the moment the pump stops so that there is ample time to remedy the trouble or start an injector before the water reaches the low limit.

An old steam gage was provided with an insulated pin at the zero pressure point and the gage grounded electrically at another point. This gage was connected on the boiler feed line as shown in sketch and electrically to a 110-v. line through a bell ringing transformer and bell or automobile horn as shown.

When the pump stops, the pressure in the line drops and the hand reaches the zero pressure point, closing the circuit and thus ringing the bell or blowing the horn.

This device may also be used in connection with a centrifugal pump. When the pump is steam bound, the insulated pin should be set at a higher point than zero pressure because a pump under this condition does not, on stopping, release all of the pressure on the feed line and the hand would not come back to zero. The insulated pin should, therefore, be set at a point a little above the static pressure point.

Detroit, Mich. LEO FREY.

## Heat Aids in Removing Crankpin

SOME TIME AGO, the country machinist guaranteed to make a new crankpin for our 15 by 30-in. engine which would fit perfectly both the crank and the connecting-rod, but he would have nothing to do with removing the damaged pin or with forcing the new one into the crank. This declaration was made after the heaviest sledge-work possible had failed to budge the damaged pin.

Instructions were given to the machinist to take measurements and proceed as far as possible with the making of a new pin, while the old one was being removed by "home-grown" methods. A ram, consisting of a piece of 3-in. shafting about 12 ft. long was rigged up for furnishing the driving power for removing the old crankpin. The shaft was suspended by a piece of stack guy-wire cable in such a manner that the shaft, when swung endwise, could be made to strike against the back end of the crankpin.

A piece of timber was clamped to the engine bed in such a manner as to be firmly fixed about 6 in. from the back end of the pin. A shallow V-groove was cut in the upper side of the timber in such a manner that a piece of old steam pipe, through which the 3-in. shaft would slide easily, could be bolted fast in the groove and lie square with the back end of the crankpin. One end of the steam pipe was left free, and temporarily supported upon a block, which was removed after one end of the swinging shaft-ram had been inserted in the pipe. This was intended to serve as a guide for the striking end of the ram.

When the ram was in use, a double-faced hammer was held against the end of the crankpin, while two men swung the shaft-ram against the hammer, transmitting the force to the crankpin.

After just one powerful blow had been struck by the suspended ram, a "dolly" was rigged to relieve the engine crank of the heavy bombardment to be delivered by the swinging ram. A piece of pipe was slipped over the crankpin and the other end of the short piece of pipe was given a solid bearing against the end of a stout piece of timber which lacked a few inches of reaching to a solid wall directly opposite the crankpin. Two big wooden wedges were driven between the end of the timber and the wall permitting all slack to be taken up in the timber and the pipe.

Heavy striking by the swinging ram failed to start the crankpin and the "dolly" arrangement was temporarily removed and the crankpin moved downward by turning the engine pulley. Some loose bricks were piled around the end of the crank, leaving a couple of inches of space between bricks and the crank. This space was filled with small pieces of charcoal and the blast from two large blow-torches turned into the charcoal through holes left for them in the brickwork. Almost instantly, the charcoal became a mass of roaring, white flame and in about 20 min. the cast-iron crank was as hot as was considered safe. Then, the crankpin was swung back into hitting position and the pin was started out of the crank by the third blow struck.

In driving the new pin into place, the positions of the ram and the dolly were reversed, the timber, clamped to the engine bed being unnecessary in this case, as the pipe which guided the ram was supported by the crankpin. The intermediate two-faced hammer

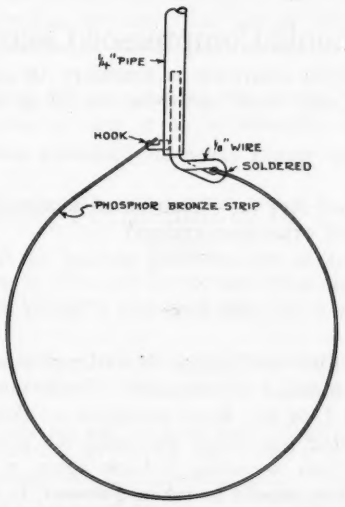
was also not necessary as the ram struck directly against the end of the crankpin. However, the brick furnace and blow-torches were used again, a heat being taken upon the end of the engine crank before attempting to drive the new pin into place.

Indianapolis, Ind. JAMES F. HOBART.

## Simple Wrench for Removing Gage Bezel Rings

REMOVING BEZEL rings of pressure and similar gages is sometimes difficult without use of some device to hold the ring. A simple wrench for this purpose, that anyone can make easily from scrap parts, is shown in the sketch.

Into a ¼-in. pipe, which is used as a handle, the end of a wire loop is fastened, the loop portion having been passed through a hole in a phosphor bronze strip, 3/64 in. thick, ½ in. wide and long enough to fit over




METAL STRIP CLINCHES ON BEZEL RING WHEN HANDLE IS PULLED AWAY FROM HOOK

the bezel ring. After connecting these two parts, they are soldered together. A ⅝-in. hole is drilled into the other end of the phosphor bronze strip which fits over a ¼-in. hook in the handle.

To apply the wrench, the strip is placed around the bezel ring and fastened to the hook. By pulling the pipe handle in a direction away from the hook, the strip grips the bezel ring and causes it to be unscrewed without difficulty.

Holtwood, Pa. E. L. FAUTH.

## How Thick Is an Oil Film?

TO MEASURE the thickness of an oil film is more difficult than it might seem. Any shaft in a babbitted bearing rises and falls more or less, depending upon the load and the lubricant used. By measuring with a micrometer the rise and fall of the shaft, it should be possible to measure the thickness of the oil film at any time, should it not? Yet, as indicated in the following, there is a vast difference in results that have been obtained by various scientists.

Professor John Goodman is a famous English scientist. He states that the thickness of an oil film varies from 0.02 at its maximum to 0.0001 in. at its minimum, just before seizing occurs.

Not only is there a vertical fall but there is a "horizontal shift." Professor Goodman says:

"It is found that the vertical lift and horizontal shift are greatest when the load and temperature are low and the viscosity and speed are high."

In discussing bearing performance, H. A. S. Howarth, General Manager and Chief Engineer of the Kingsbury Machine Works, says:

"There are many bearings that start under full load and with adequate lubrication. Their friction coefficients at starting would vary from 0.15 to 0.20, or about 100 times the minimum coefficients that the author obtains. As such journals gather speed, their friction coefficients *fall off* rapidly to about one-hundredth of the starting value. From that point on, the coefficient *goes up* with the speed. The fact that a vast number of bearings start and stop frequently without injury proves that they can pass through the regions of 'unstable' and 'stable' lubrication with impunity.

"In the region of stable lubrication, oil passing between the bearing surfaces produces fluid friction, the heat from which in a full bearing can be dissipated throughout the circumference, even though at low speeds it is nearly all produced at the region of nearest approach of the surfaces. As the speed slows down through the range in which metallic rubbing is increasing, the amount of oil passing through the region of close approach decreases. It is here that we may look for trouble when the area of contact is so small that the heat cannot be conducted away fast enough to prevent the overheating of the bearing metal.

"We do not know the generalized speed at which this metallic contact would become dangerous. The oil film would be more persistent in a bearing with small clearance than in one with large clearance. Hence we should expect the one with small clearance to run without harm at lower speed than the one with large clearance."

G. B. Karelitz, Research Engineer for the Westinghouse Electric & Manufacturing Company, wrote:

"Dr. T. E. Stanton found, in a bearing of phosphor-bronze on a steel journal of 1-in. diameter, the values 0.000054 in. and 0.000046 in. for the minimum oil thickness.

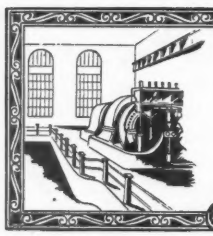
"On the other hand, direct measurements on a large industrial motor by V. Vieweg showed the thickness of the oil film when rupture starts to be of the order of 0.00040 in. These were lead-base babbitt bearings with a steel journal."

So you see there is considerable difference in opinion even among the foremost scientists regarding minimum thickness of an oil film. Of course, it is logical that the material of which the bearing is made has much to do with the thickness of the thinnest film possible.

A. C. Becker of the Standard Oil Development Company, Elizabeth, N. J., said this:

"Certain oils have film thicknesses as little as 0.0006 in. In all cases, regardless of how thick the minimum film is that can be measured, the indications are that the film breaks down very suddenly and the breaking-down point depends on the oil used as well as on the bearing metal."

Newark, N. J. W. F. SCHAPHORST.

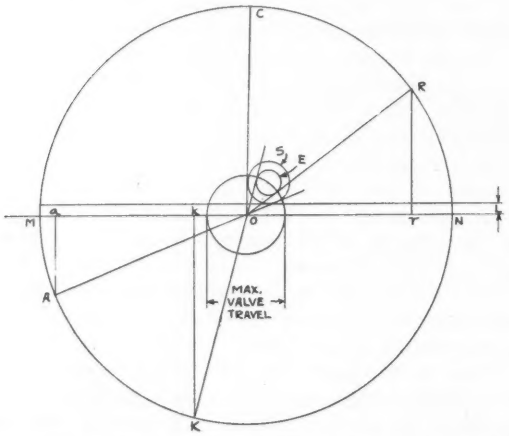


# QUESTIONS AND ANSWERS

## Determination of Point of Compression

YOUR ANSWER to the following would be greatly appreciated:

How would you find the point of compression if a slide valve had a lead of ⅛ in., a lap of ¼ in., the cutoff occurred at ½ stroke and release at 9/10 stroke? Can this be found by means of the Bilgram diagram if




LENGTH OF STROKE NOT REQUIRED TO DETERMINE POINT OF COMPRESSION BY MEANS OF BILGRAM DIAGRAM

the length of the stroke and that of the connecting rod are not known? J. T.

A. Using the Bilgram diagram, draw a circle representing piston travel to any convenient size as MN with center at O; in this case let MN equal 5 in. Since this circle represents only proportional distances, it is not necessary to know the length of the stroke of the engine in order to find the point of compression by means of the Bilgram diagram.

Because the connecting rod is usually comparatively long, its angularity is often neglected and it is considered as a connecting rod of infinite length. This, however, does not give accurate results.

Since the cutoff is at 50 per cent, it is halfway across the stroke and, therefore, the crank would stand in a vertical position as at OC when cutoff takes place. Release you give at 9/10 stroke, hence the point r would be 9/10 of the distance from M to N. Projecting this upward until it intersects the stroke circle at R gives us OR as the position of the crank at release. The lead is given as ¼ in. This is laid off at L. With a radius equal to the steam lap, which is ¼ in., draw the circle S tangent to the cutoff crank position and the lead. With the same center, draw the exhaust lap circle E tangent to the crank position at release OR. To find the crank position at compression, draw a line through O tangent to the exhaust lap circle and extend this to the stroke circle at K. Projecting this upward to k and taking the proportional distances Nk ÷ NM and substituting their measured distances, we have 3.12 in. ÷ 5 in. = 62½ per cent, which gives the point of compression. Likewise we find the point of admission by taking the proportional distances Na ÷ NM and substituting their measured values as before, we have 4.77 in. ÷ 5 in. = 95½ per cent as the point of admission.

## Ammonia Compressor Clearance

HOW MUCH clearance is necessary in an ammonia compressor and what would be the effect of excessive clearance?

2. What would cause an ammonia compressor to burst?

3. When does the expansion of ammonia take place in the direct expansion system?

4. What is the practical method of defrosting a refrigerating coil?

5. How would you thaw out a frozen brine cooler?

C. E. D.

A. As little mechanical clearance as possible should be given ammonia compressors. Some manufacturers recommend 1/64 in. Some operators set their clearance by unscrewing the piston rod until the piston hits the head and then screwing it back again a very small amount. Care should be taken, however, to see that the amount is large enough to prevent knocking after the compressor has been heated up as the expansion in the rod due to the heat reduces the amount of clearance set when cold.

In adjusting the clearance in a double-acting compressor, the piston rod is unscrewed, when the compressor is at one dead center, until the piston strikes the cylinder head. The rod is then marked, after which the crank is turned until the compressor is at the opposite dead center when the piston is caused to strike the head as before and the rod again worked. Observing the two marks, the piston is now unscrewed until it is at a point midway between the two extremes indicated by the marks on the rod. This equalizes the clearance.

2. If too much air is mixed with the ammonia, an explosive mixture may result when the gas is compressed. It is wise, therefore, to test the gas at the purge valve periodically and if air is found in the gas, steps should be taken to remove it from the system.

Slugs of ammonia liquid coming over into the compressor would cause the cylinder head to be broken or thrown off, but such slugs are not likely to be drawn into the cylinder if the machine is properly operated.

3. Expansion of ammonia takes place in a direct expansion system as soon as there is a drop in pressure

between two parts of the system. If the drop is considerable, the liquid ammonia flashes into a gas.

4. Probably the best way to defrost a refrigerating coil is to shut off the suction; this will cause a rise in temperature after which the ice can be quickly removed by tapping the pipes with a hammer. Another way is to run warm gas back through the discharge side of the system. In doing this, care should be taken to open the necessary valves very slowly. Automatic expansion valves are provided with a defrosting system through which warm gas flows.

5. A frozen brine cooler may be thawed by stopping the circulation of ammonia by closing the expansion valve and raising the pressure by operating the pump. For this purpose, it is good to install a check valve which is provided with an arm sticking out at the side, which will protrude out farther as the pressure rises and by making an electric contact light a red light and ring a bell when the limit of pressure which would indicate that the pipes were frozen up has been reached. As the pressure increases, the flow of brine decreases and this causes the check valve to work closer to its seat.

It is well when operating the pump under these circumstances to slow it up occasionally and try out the system.

## Magnetic Permeability of Iron and Steel

MAY I ASK, what are the permeability characteristics of different kinds of iron and steel used for electrical purposes? J. H.

A. The table gives the maximum magnetic permeability for untreated metals, also when they are hardened by heating to cherry-red color and quenching in water and when annealed by heating slowly to 1472 deg. F. and then causing them to cool as slowly as possible.

TABLE GIVING MAXIMUM MAGNETIC PERMEABILITY OF VARIOUS KINDS OF IRON AND STEEL

| | Chemical Composition in per cent | | | | | Maximum Permeability | | |
|---|---|---|---|---|---|---|---|---|
| | C | Si | Mn | P | S | Untreated | Quenched from cherry-red | Annealed at 1472° F. in vacuum |
| Electrolytic | 0.024 | 0.004 | 0.008 | 0.008 | 0.001 | 2.83 | | 0.36 |
| Good Steel Casting | 0.044 | 0.004 | 0.40 | 0.044 | 0.027 | 1.51 | | 0.37 |
| Poor Steel Casting | 0.56 | 0.18 | 0.29 | 0.076 | 0.035 | 7.1 | 44.3 | |
| Steel | 0.99 | 0.10 | 0.40 | 0.04 | 0.07 | 16.7 | 52.4 | |
| Cast Iron | 3.11 | 3.27 | 0.56 | 1.05 | 0.06 | 11.4 | | 4.6 |
| Elect.-Sheets-ordinary | 0.036 | 0.33 | 0.26 | 0.04 | 0.069 | | | 1.30 |
| Elect. Sheets - Si. steel | 0.036 | 3.90 | 0.09 | 0.009 | 0.006 | | | 0.77 |

## Corliss Engine Operation

PLEASE GIVE ME information on the following:

1. Will a long range Corliss engine race if the load is suddenly taken off?

2. What extra precaution must be taken in setting valves of a long range Corliss engine?

3. Describe the proper method of starting a cross-compound engine which is supplied with an independent jet condenser? M. L. S.

A. A long range or long stroke engine is more likely to race when the load is suddenly removed than would be the case with a short range engine because the periods between the time during which the governor controls the amount of steam admitted into the cylinder are longer in the case of the long range engine than in the case of the short range engine, hence the former type of engine has a correspondingly long period in which to speed up.

2. Because of the above, greater care must be taken in setting the point of cutoff, especially in avoiding a cutoff of too great length.

3. If the exhaust line runs down and then up again, it should be bled out before starting the engine. The exhaust line between the two cylinders should also be drained. The process of starting is then first to start the condenser and pump a vacuum, then admit steam to the engine, slowly at first, so as to warm it up gradually and permit any condensate to be drained through the exhaust valves.

## Questions on Refrigeration

WILL YOU PLEASE answer the following questions:

1. What would be the most important duty of an engineer of a refrigeration plant in case of a disastrous fire?

2. What is the usual life of brine piping?

3. What is the usual life of direct expansion piping?

4. What should the safety valve be set at on the discharge line of an ammonia refrigerating system?

5. What would be the effect of using brine for condensing instead of water? R. P.

A. The most important thing for an engineer of a refrigerating plant to do in case of fire is to pump the ammonia out of the building in which the fire has occurred, if there are several buildings in the plant, or out of that part of the building where the fire exists, if possible. If the fire should occur directly in the engine room, he could probably do nothing but shut down his engine and close all valves.

2. The life of piping depends much upon the conditions under which it is used. If no acid or air came in contact with steel pipe, it would last indefinitely. Some set the limit of life of cast-iron pipe for brine circulation at from 2 to 10 yr.—others at from 5 to 20.

3. The life of direct-expansion piping is usually taken as from 5 to 20 yr., depending upon the conditions of its use.

4. The safety valve on the discharge line of an ammonia system should be set and sealed at 300 lb. pressure.

5. The effect of using brine instead of water for cooling a condenser would be to shorten considerably the life of the condenser. There would be nothing gained by this procedure, as a greater amount of deposit would be formed by the brine than by water and less heat would therefore be abstracted.

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P. H. SCHWEITZER, associate professor of Engineering Research at The Pennsylvania State College, is going abroad to take his Doctor's degree at a German university. Professor Schweitzer is in charge of the Diesel oil spray research at Penn State. During his absence, K. J. De Juhasz will substitute for him in conducting the investigation.

# EDITORIAL COMMENT

## Repairs in the Plant

In earlier days, when machine shops were less convenient of access, the operating engineer was, of necessity, a trained mechanic, familiar with the use of tools, both machine and hand and capable of devising ways of doing things for which there were no tools. A plant had its own machine shop, large or small, and depended on its own resources.

With the increase of outside shop facilities, repairs and emergency construction went to them, so that the plant shop largely disappeared. This was a natural result of specialization but did not improve the status of the plant engineer, as it lessened the requirements for responsibility and ingenuity on the part of the man in the plant.

It is a debatable question whether the work has been better done but there can be none as to the effect on the interest and responsible demands of plant operation.

Two factors are operating to bring back the power plant shop. One is the use of such large units that sending them away becomes a long and expensive procedure; the other is the intensive specialization of manufacturing, which makes outside shops unwilling to interrupt their regular routine and leaves them less fitted to handle special jobs.

With a few machine tools fitted to the size of units and requirements of a plant, a varied and adequate, though not necessarily large, outfit of hand tools and a man in charge who has experience and initiative, most repairs, overhauling and even replacement of parts can be done satisfactorily in the plant. First cost of the shop need not be large, work will generally be completed more quickly than when sent outside and there would seem a good likelihood of reducing expense. Often, too, changes and special devices can be made, which would be delayed or omitted, if outside expense were involved. It is likely that the manufacturing end of the plant, as well as the power house, will be benefited by the availability of such machine shop equipment and skill.

At any rate, here is an opportunity which it is worth every power plant manager's while to study, as a means of reducing costs, increasing effectiveness and adding usefulness in his department.

## Language and the Power Plant

Wherever engineering matters are discussed, the question of coöperation between the management and engineering departments will eventually come up. Often relations between the two departments are somewhat strained, if not actually antagonistic.

Fundamentally, the natural thinking languages of the two are different; one thinks in terms of dollars—the other in terms of heat units. Regardless of the right and wrong of the situation, the manager is admittedly at the top and in a position of authority so that in self-defense the engineer must forsake his natural element and climb on the band wagon yelling dollars.

Perhaps it is proper for the engineer to sit back and rest on his laurels, feeling that, in its wild rush of progress, the world will seek him out to do bigger and better things. It's not good business, however, and the world has a disconcerting way of forgetting about an individual unless that individual has a good press agent.

Perhaps the engineer has a right to feel a little conceited, knowing that he has the technical knowledge and ability to do new and unheard of things but, after all, the manager has the same right to a conceited feeling, perhaps a better right, because he has the combination to the safe. Without money and financial assistance, the engineer can do nothing but sit back and twiddle his thumbs.

By refusing to speak any but his own language, he is placing himself in the position of the Englishman who, after living a short while in Mexico, wrote back: "Delightful country but beastly stupid creatures—been here six weeks and none of them speak English yet."

If two languages are necessary for the proper conduct and advancement of the power plant, it behooves the engineer to speak both of them and not depend upon others to learn his language.

## The Guild System – 1928 Model

Students of the development of industry are familiar with the guild system that rose to its greatest power in Europe in the 14th century, following the period of the handicraft system and preceding the development of machinery that brought about the industrial revolution. They will be interested to learn, therefore, that an American manufacturing company, according to an article in the Nation's Business, has been successful in combining certain features of the old guild system with its modern quantity production system, employing many types of machinery and labor-saving devices.

Perhaps the outstanding characteristic of the ancient guilds was the apprenticeship system, under which no man could ever rise to be head of a particular industry or even to be a journeyman workman until he had served a long apprenticeship while a young man. The system had its hardships and its disadvantages but it did two things. First, it gave every man a thorough knowledge of the existing manual technique of his field; that is, any member of the guild was qualified to perform any part of the work himself, beginning with the design. Second, the natural results of this were pride of craft and, in consequence, production of all sorts of materials of the highest quality and even in some cases, works of art. Products of the guilds were expensive, of course, and could be purchased only by the wealthy.

Now the manufacturer referred to above has adapted the apprenticeship feature of the guild system by starting at the top and requiring executives to work in the factory three afternoons a week. Conversely, the advanced workmen are given an opportunity to learn something of executive problems by attending training classes for sales representatives. Besides this, a training course in the whole industry is conducted for young college graduates. The advantages of this procedure are obvious.

This idea, however, is not at all new to the power plant engineer. Certain of the larger manufacturing industries have conducted various types of apprenticeship courses but these have not, as a general rule, touched the executives who rose from the ranks before the present quantity production methods came in. Yet we venture to say that there is scarcely a power plant executive of any consequence, central station or industrial, who has not served an apprenticeship in overalls and who could not don them again and serve acceptably as an operating or watch engineer.

This is not because power development has been slower; we all know that the contrary is true. It is because the old guild idea has persisted in the power plant up to the present day more strongly than in any other industry. Physical operation and executive management in power plants cannot be put in separate water-tight compartments, as they are in some industries. The very nature of the work demands executives who know the technique.

Not long ago the editor, visiting a 100,000-kw. central station, found the plant superintendent in the boiler room, just in the act of coming out of a boiler drum. One of the stoker operators remarked, "Well, the Old Man wants to see for himself and he knows what to look for and how to fix it." Needless to say the ésprit de corps of that station was high. That is not an isolated case but a typical example. The ancient guild system and the spirit engendered by it have a strong foothold in the power plant.

## Off Duty

It is strange that with the enormous growth of our cities so few people are willing to admit that cities have anything but evil qualities and that they are anything but extreme necessities in which people are compelled to live contrary to their inclinations. Prophets, everywhere, proclaim movements away from the big cities—articles and radio addresses mark the decentralization of industry with a consequent exodus of people to the country where they can live in peace and quiet in a wholesome atmosphere. Politicians of every species eulogize farm life and heap encomiums upon the son of the soil. Preachers shout the evils of the city from the pulpits and deplore its influence upon the populace.

In the meantime, the cities grow. More and more people, every year, come to live in cities. Villages grow into towns, towns into small cities, small cities into larger ones. The great cities become greater.

This being the case, surely the city cannot be so utterly bad or if it is, humanity as a whole must prefer evil to good.

True, cities are dirty—there is soot and dust in the air and the sunshine may not be as bright as it is in the country, but for this reason, perhaps, the sunshine is more appreciated. If dirt is more prevalent, it is easier to keep clean—with unlimited running water, laundries in every block, cleaning establishments galore, city people don't have to tolerate dirt.

The criticism is made that in cities, social acquaintance is difficult—that one doesn't know one's neighbors even though they live together for years. While in a measure, perhaps, this charge is true, it has its advantages. In the city one's privacy is more respected than in smaller towns. The city is more tolerant and kindly toward one's personal opinions. It doesn't pry into one's personal affairs and as long as one does not interfere with the opinions and liberties of others, one may harbor any opinion, political or otherwise, or be of any religion, sect or creed without interference or condemnation from others. Though this may be nothing more than indifference, the characteristic is to be desired.

Socially and culturally the city offers all that even the most ambitious could desire. With its great theatres, its parks, its churches of all denominations, its clubs and restaurants, its libraries and museums, its schools and art galleries and concert halls, every cultural or social impulse of an individual or group can be satisfied.

Cities are the natural product of civilization. Since the beginning of history, the great civilizations which have preceded our own have been due largely to the springing up of cities. If we view history as an economic development, it is perhaps the rise of metropolitan communities rather than that of soverign states that counts. In cities people lose to some extent their more animal natures—they become more tolerant of each other.

That the city is dependent for its food supply upon the farmer is not to be denied but the reverse is equally true in regard to the material things the farmer uses. No farmer today is self-existent. True, by returning to the primitive he could become self-existent but the same is true of his city cousin. Almost everything the farmer uses, including much of the food he eats, as well as the machinery he uses, is city made. He may raise his own potatoes and pork and may even grind his own flour but his spices, his sugar, his salt, tea and coffee, chocolate, many of his fruits, if not actually produced by city men are refined and distributed by them. The clothes he wears are all city made as is the automobile he rides to town in.

To love the city—its excitement, its restlessness, its romance, does not imply dislike for the beauties of nature. Of all people, the city man, when he does go out in the country, into the mountains or out on the seas, is perhaps most appreciative of nature's charms. He worships them in a way that those who are not of the city can never understand.

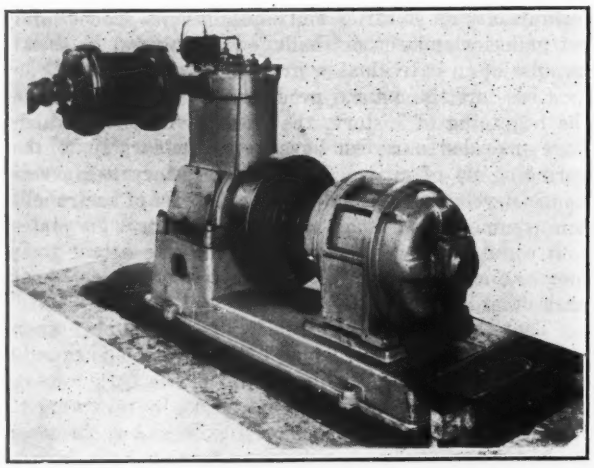
The city is life. A city, says Elihu Root, is a growth like that of a crystal responding to forces inherent in the atoms of which it is composed. This force from which that growth comes is the force of individual enterprise based on the desire for movement, for wealth, for comfort, for society; all these desires existing in the hearts and acting on the minds of a vast number of units. This is the great force of civilization.

Because this force is unrestrained—uncontrolled, cities are not perfect. There is vice, there is corruption, there is poverty, but despite these evils, the city has done more toward the steady uplift of the human race than perhaps any other single factor in history.

# POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

## Air Compressor Discharge Silencer

WITH SMALL, high-speed air compressors, there is often a rather severe noise in the receiving tank on the discharge side of the compressor. This noise is created by the rapidity with which the discharge valve



SILENCER ON DISCHARGE SIDE OF SMALL COMPRESSOR

of the compressor seats at the end of the compression stroke. Tests have shown that the noise is not mechanical nor caused by the machine itself but is an air phenomenon. The noise is usually severe enough to penetrate the walls of the receiving tank and some of the piping, because the air in which it exists is at high pressure and consequently greater density.

To go in the discharge pipe of the compressor directly after it leaves the machine, a new type of silencer shown here has been designed. It is designed to pass the compressed air with negligible resistance but to eliminate the discharge noise to a point where it can hardly be heard.

This silencer, brought out by The Maxim Silencer Co., Hartford, Conn., is designed to be extremely simple, small and easy to install. Connection to and from the silencer is made by means of a standard pipe thread, one at the center of the inlet head and one at the center of the outlet head. The silencer casing is designed for 125 lb. per sq. in. working pressure.

Use of this silencer is intended to allow the installation of small, high-speed, inexpensive compressors in locations where quiet operation is absolutely essential. This applies to schools, office buildings, hospitals and the great variety of similar buildings in which compressed air has come to play such an important part. The receiving tank can be located wherever it is convenient.

## Removable Air Boxes for Underfeed Stokers

IN MANY installations of underfeed stokers, secondary air is admitted over the fuel bed through hollow refractory blocks set in the brickwork of the front wall. When it is desired to renew these blocks, it is necessary

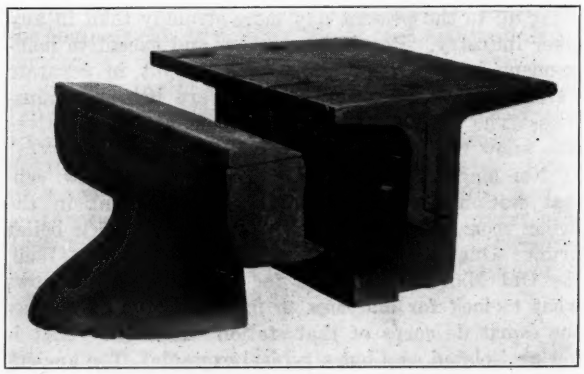


FIG. 1. AIR-DISTRIBUTING BOX AT LEFT AND FRONT WALL SUPPORT AT RIGHT

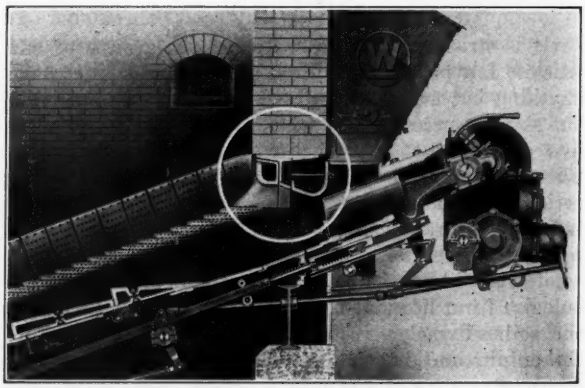


FIG. 2. FRONT WALL IS SUPPORTED BY T CASTING AND AIR BOXES ARE REMOVED WITHOUT DISTURBING BRICK-WORK

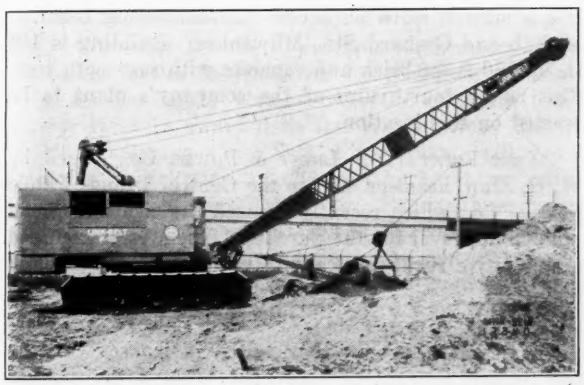
to tear out the brickwork around them, to remove them and then to rebuild the brickwork after the new blocks have been set.

To eliminate the expense of doing this, the Westinghouse Electric & Manufacturing Co., East Pitts-

burgh, Pa., has developed for its stokers removable, cast-iron, air-distributing boxes and independent, front wall support, forming integral parts of the stoker structure. One box and one front wall support casting are provided for each retort, as shown in Fig. 1. Figure 2 shows how they are installed. The full load of the front wall is transmitted through the T castings directly to the main supporting steel of the stoker. Air boxes may be removed and new ones installed without disturbing the T supports, therefore without tearing down any front wall brickwork. The T castings are not subjected to heat and for that reason are claimed to be practically indestructible.

## Link-Belt Announces New 2-Yd. Shovel

ANNOUNCEMENT is made by Link-Belt Co., Chicago, Ill., of the addition of a full 2-yd. capacity machine to its line of crawler cranes, shovels and draglines. Heretofore the largest capacity machine built by



NEW K-55 MACHINE OPERATING AS A DRAGLINE

this company was a 1½-yd. unit. The Link-Belt K-55, as the new machine is known, is primarily designed for the following adaptations: as a shovel with 30-ft. boom and 18-ft. dipper stick carrying a 2-yd. struck-measure-capacity all-manganese-steel dipper; as a dragline to handle 2-yd. dragline bucket, for medium and medium-heavy excavating, on boom 50-ft. long, or a 1½-yd. dragline bucket on boom 60 ft. long; as a clam-shell bucket of 2-yd. capacity, for sand, gravel or materials of equal weight per cubic foot and consistency, on boom 50 ft. long or a 1½-yd. bucket, in such materials on boom 60 ft. long or an equivalent weight of loaded bucket in heavier or lighter materials; as a trench shovel, 2-yd. capacity.

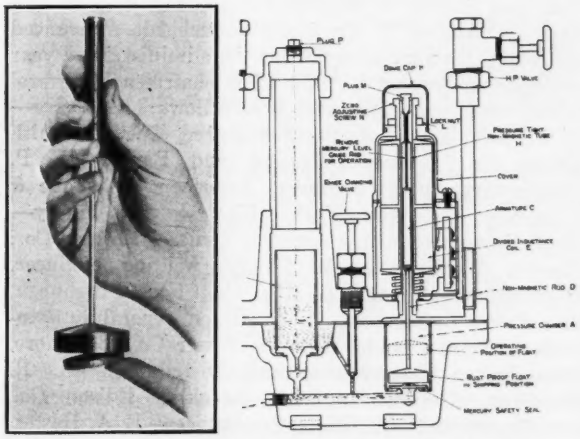
All attachments are designed to be interchangeable without removing or disturbing the mechanism of the machine proper. Special clearance-reducing arrangement is provided to make it possible to ship the machine from place to place without dismantling.

Unit cast steel construction of lower and upper frames is a feature, also self-cleaning crawler treads, large bronze-bushed crawler rollers, enclosed cut gearing and bronze-bushed bearings. Internal expanding friction clutches are provided; a 13½-in. diameter center pin, adjustable from above, can be removed as a unit with the vertical travel shaft assembly, without removing any other parts; large drums with renewable cast steel shells are used, having air space between clutch and brake surfaces, for rapid cooling. Drum brakes are 48 in. in diameter by 5 in. wide. The machine in working condition is 12 ft. wide overall at the lower frame and crawler treads are 36 in. wide. The K-55 is built to be driven by gasoline engine, electric motor or Diesel engine.

## Blow-out Check for Brown Flow Meter

FOR APPLICATION to Brown electric flow meters, a mercury blow-out check has recently been developed, as shown, for the manometer of the meter. The purpose of this device is to prevent an abrupt and violent increase in flow beyond the maximum capacity of the manometer from blowing out all or part of the mercury.

This check consists of a resilient disc, flexibly attached to the bottom of the float and a seat machined in the manometer body. If the downward travel of the float exceeds the value for maximum flow, the disc is dropped onto the seat, which closes the passage from the high-pressure leg to the low-pressure leg. The disc, being flexibly mounted, is free to seat itself instantly and tightly when the slightest excess flow occurs, thus preventing



LEFT—DISC ON BOTTOM OF FLOAT CLOSES MERCURY PASSAGE
RIGHT—POSITION OF FLOAT AND CHECK IN METER

the upstream pressure from blowing mercury out of the downstream side. Further increase in flow simply makes the seal tighter. When flow returns to normal the disc is lifted and normal action is resumed automatically. It is made by The Brown Instrument Co., Philadelphia, Pa.

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ILLINOIS COMMERCE COMMISSION has authorized the Illinois Public Service Co. to build and operate a 6500-v. electric line from Macomb, McDonough county, to Littleton township, Schuyler County and the Central Illinois Public Service Co. to erect a 33,000-v. line between Jerseyville and Brighton.

# News Notes

AT THE 17TH ANNUAL SAFETY CONGRESS to be held at New York City September 31 to October 5, discussions of safety applied to various types of power plants will be given prominence. At the meeting of the Public Utilities Section on October 2, there will be addresses by Dr. James S. Thomas of the University of Ala., H. B. Harmer of the Philadelphia Electric Co., George Opp of the Detroit Edison Co. and other prominent engineers. At the Refrigeration Section, also meeting October 2, addresses will be made by Wesley Oler of the Knickerbocker Ice Co., Vincent Wakefield, treasurer of the City Ice Co., who is also chairman of the Refrigeration Section and L. C. Smith, Secretary of the National Association of Ice Industries.

ANNOUNCEMENT IS MADE that the Seventh National Exposition of Power & Mechanical Engineering will be held at the Grand Central Palace, New York City, December 3-8, 1928. This will include many exhibits of heating and ventilating equipment, transmission equipment and wood and metal working tools, in addition to the varied display of equipment particularly for the power plant.

TWENTY-FOURTH ANNUAL CONVENTION of the Empire State Gas & Electric Association will be held at Saranac Inn, Upper Saranac, N. Y., on Thursday, Sept. 20, and Friday, Sept. 21.

AT A MEETING of the Board of Directors of the American Society of Electrical Engineers, held in New York on August 7, President Schuchardt announced the committee appointments for the administrative year commencing August 1, 1928. The chairmen of several of the committees appointed is as follows: Executive—R. F. Schuchardt, electrical engineer, Commonwealth Edison Co., Chicago; Meeting and Papers—H. P. Charlesworth, plant engineer, American Telephone & Telegraph Co., New York; Electrical Machinery—W. J. Foster, consulting engineer, General Electric Co.; Electric Welding—A. M. Candy, welding engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.; Power Generation—F. A. Allner, general superintendent, Pennsylvania Water & Power Co., Baltimore, Md.; Power Transmission and Distribution—H. R. Woodrow, electrical engineer, Brooklyn Edison Co., Inc., Brooklyn, N. Y.; Protective Devices—E. A. Hester, planning engineer, Duquesne Light Co., Pittsburgh, Pa.

OSTER MFG. CO., Cleveland, Ohio, announces the recent election of A. S. Gould as secretary of the company. Mr. Gould has been sales manager of the company for 10 yr.

JOHN H. BODE has resigned as president and general manager of the Wellman-Seaver-Morgan Co., Cleveland and has been succeeded by George W. Burrell, formerly vice-president, who retired two years ago to take a rest after 27 yr. of affiliation with the company. Mr. Bode had been with the company about two years.

W. B. FOSHAY CO. announces that Wm. H. Grove, former director, president and treasurer of the Century Engineering Corp. at Newark, N. J., has joined the Foshay staff. Mr. Grove has been prominently identified with the electrical industry as president of the Grove Electric Corp., consulting engineer and member of various technical and scientific societies. In his new connection, he will be assistant to the president of the Public Utilities Consolidated Corp., the utility operating company for Foshay interests.

M. M. HEDGES has been named president of the Hedges-Walsh-Weidner Boiler Co., Chattanooga, Tenn., formed recently by a merger of the Casey-Hedges Co. and the Walsh & Weidner Boiler Co.

KEASBEY & MATTISON CO., Ambler, Pa., announces that Wm. Jacobsen, recently with the Asbestos & Mineral Corp. of New York City, has been appointed sales manager of its fiber department.

WAGNER ELECTRIC CORP., 6400 Plymouth Ave., St. Louis, Mo., announces that A. E. Herzberg, manager of transformer sales division, was promoted on August 3 from the grade of major in the U. S. Army Reserve to the grade of lieutenant-colonel.

ERIE CITY IRON WORKS, Erie, Pa., announces that it has appointed Alan G. Cary & Co. as its sales representative in St. Paul, Minn.

CHAIN BELT CO., Milwaukee, Wis., announces that it has started work on a new manufacturing building at 39th and Orchard Sts., Milwaukee. Building is 104 ft. by 150 ft. of brick and concrete with saw-tooth roof. This is the fourth unit of the company's plant to be erected on this location.

WEST POINT (Ill.) LIGHT & POWER CO., owned by W. G. Zinn, has been sold to the Central Illinois Public Service Co., which recently secured the commerce commission approval for the purchase. The system included an extensive rural service with power from the Keokuk dam.

EDWARD VALVE & MFG. CO., East Chicago, Ind., announces that it is now represented in Kansas City by the Smiley Equipment Co., 1737 Walnut St., Kansas City, Mo. It also announces that its Houston representative, the Maintenance Engineering Corp., has moved to new headquarters at 1400 Conti St., Houston, Texas.

DUST COLLECTION by the Norblo system has been installed by the Lawrence Portland Cement Co. at its Rockland, Me. plant and by Marquette Cement Co. at its La Salle, Ill. plant. In the latter plant, besides acting to collect dust, it is found that the system improves ventilation and increases the output of the screens due to removal of moisture. The systems were supplied by the Northern Blower Co., Cleveland, Ohio.

AT A MEETING of the Board of Directors of The New York Edison Co., held Aug. 28, the following changes in the executive officers were made: Nicholas F. Brady resigned as president of The New York Edison Co. and was elected chairman of the board of directors. Thomas E. Murray, senior vice president, has been elected vice chairman of the board. Matthew S. Sloan, president of the Brooklyn Edison Co., has been elected a director and president of The New York Edison Co., in complete charge of all operations, policy and management. Mr. Sloan will also continue to act as president of the Brooklyn Edison Co. John W. Lieb, vice president, has been elected senior vice president of The New York Edison Co.

FOLLOWING THE RECENT application of the Empire District Electric Co., Joplin, Mo., to the Federal Power Commission for authority to build a hydroelectric power plant on the White River, the company is reported arranging preliminary plans. It is proposed to build a power dam 195 ft. high near Springfield to cost more than $20,000,000. The company is a subsidiary of the Cities Service Power & Light Co., controlled by Henry L. Doherty & Co.

AT THE REQUEST of the Soviet government, a special commission, composed entirely of Swedish hydraulic, electrical, mechanical and architectural engineers, will go to Russia during the present summer for the purpose of making further studies of the proposed hydroelectric project of the River Swir, north of Leningrad. The commission will be headed by Professor Hornell of the Royal Technical University and will include three engineers from Vattenbyggnadsbyran, the largest firm of consulting engineers in Sweden, one consulting electrical engineer and the construction engineer for Kreuger and Toll Aktb. The preliminary design, which has already been worked out by Vattenbyggnadsbyran, includes an Ambursen type dam in which several structural innovations will be employed.

CONTRACT for the power house generators to be installed in the Saluda River hydroelectric development of the Lexington Water Power Co. of South Carolina was recently awarded to the Westinghouse Electric & Manufacturing Co. This power plant will have an initial installation of 200,000 hp. and an ultimate capacity of at least 300,000 hp. Four turbines will first be installed, each of 50,000 hp. capacity. They will be connected directly to Westinghouse generators, each of which will have a rating of 40,625 kv-a. at 13,800 v., and a speed of 138 r.p.m. New design features found in these generators include elimination of upper guide bearings and the construction of the rotor in the form of an umbrella. The thrust bearing is to be mounted in the lower bracket, under the umbrella formation of the rotor, instead of at the top, as is customary.

PAIGE & JONES CHEMICAL Co. of New York City and Hammond, Indiana, has purchased from the American Water Softener Co. of Philadelphia, patent rights and good will pertaining to lime-soda water softening business of that company and will hereafter manufacture and sell this type of softener. W. T. Runcie, formerly sales manager, and H. C. Waugh, engineer, of the American Water Softener Co., have joined the organization of the Paige & Jones Chemical Co.

# Books and Catalogs

OVERHEAD ELECTRIC Power Transmission Engineering, by William T. Taylor. J. B. Lippincott Co., Philadelphia, Pa.; 532 pages, 100 illustrations; 6 by 9 in., cloth, 1927.

Development in overhead transmission is first discussed, then follow chapters on design and construction, and on survey and location. Details of conductors, of stress, sag and span, of wood poles, steel towers, cross arms, insulators and pins are treated in several chapters. Erection of lines, protection and maintenance are discussed. And, finally, a chapter is given to studies of costs, of transmission lines, given, however, in English values.

To read completely the discussions on design, a thorough knowledge of mathematics is necessary as this topic is treated from a scientific standpoint. Practical details are, however, clearly described without mathematical formulas and in line with latest modern developments so as to give a full understanding of current practice in this branch of engineering.

Complete tables on conductor sizes and capacities, mathematical solutions of formulas, details of poles and towers, sag and tension in spans add to the convenience and usefulness of the book for transmission engineers.

OSCILLOGRAPHY is the title of a recent 16-page well-illustrated bulletin discussing the remarkable progress made during the past few years in design and application of the oscillograph. The bulletin shows the various types of apparatus now produced for commercial purposes, discussing them in a somewhat non-technical manner and showing how they are set up for operation. Schematic diagrams are also given for the benefit of the scientific investigators using this equipment. Various types of oscillographs can be applied to meet the demands of a large and diversified field of uses, ranging from the analysis of line surges on power distribution systems to the medical research field, in which they are applicable to the study of nerve impulse and muscular reaction. This bulletin, S.P. 1796, is published by the Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

DIESEL ENGINES for Central Stations are described and illustrated in considerable detail in a 40-page bulletin, No. 118, just issued by McIntosh & Seymour Corp., Auburn, N. Y. After showing typical installations and arrangements of these units in central stations, the bulletin gives data on fuel consumption, lubrication, maintenance and general operating procedure.

DETAILS OF CONSTRUCTION of heaters, steam jet air pumps, expansion joints and other products are given in a well illustrated booklet, No. 133, by the Ross Heater & Mfg. Co., Inc., Buffalo, N. Y. Dimensions of the units are shown and many engineering data are given relating to their performance and their application to various types of work.

ERIE CITY three-drum water-tube boiler and Erie City unitype pulverizer are described and illustrated in three new eight-page booklets, held together in a binder, issued by the Erie City Iron Works, Erie, Pa.

APPLICATIONS of the Lux-Rich system of fire protection in various types of work, including public utility generating plants, are shown in the August issue of Lux-Rich Reports, published by Walter Kidde & Co., 140 Cedar St., New York, N. Y.

GENERAL DESCRIPTION of the various types of American electric motors and discussion of the advantages of each and methods of manufacture are given by bulletin No. 102, issued by American Electric Motor Co., Cedarburg, Wisconsin. In bulletin 101, the company illustrates uses of these motors in various industries.

NOJOINT for monolithic linings and furnace repairs is described, with information about installing, in a recent folder issued by The Ironton Fire Brick Co., Ironton, Ohio.

# Power Plant Construction News

**Ariz., Bisbee**—The Arizona Edison Co., Douglass, Ariz., is planning the early construction of a new steam-operated electric power plant in the vicinity of Bisbee, reported to cost in excess of $75,000.

**Conn., Fairfield**—The United States Aluminum Co., operated by the Aluminum Co. of America, Oliver Building, Pittsburgh, Pa., will install power equipment in its proposed new plant on the Post Road, Fairfield, estimated to cost about $250,000.

**D. C., Washington**—The Phillip Sausage Co., 10 Wholesale Row, plans installation of cold storage, refrigerating and power equipment in proposed new two-story plant to cost about $200,000. Henschien & McLaren, 1637 Prairie Avenue, Chicago, Ill., are architects and engineers.

**Fla., Tampa**—The Pitch Pine Products, Inc., 602 Grand Central Avenue, D. C., Gillett, president, recently organized plans installation of power equipment in proposed new turpentine and pine oil plant on Forty-third Street to cost approximately $100,000.

**Ga., Royston**—The Royston Spinning Mill Co. plans installation of power equipment in connection with new one-story unit to cost approximately $100,000. Park A. Dallis, 2364 Ponce de Leon Avenue, Atlanta, Ga., is engineer.

**Ill., Chicago**—The Commonwealth Edison Co., 72 West Adams Street, has preliminary plans under way for the installation of a power substation in new Palmolive Tower Building at Michigan Boulevard and Walton Avenue.

**Ill., Chicago**—The Schultz Sausage & Provision Co., 3453 Giles Avenue, is reported planning installation of cold storage and refrigerating equipment in proposed two-story factory at Lowell and Forty-first Streets, for which bids will soon be asked on general contract.

**Ill., Cairo**—The Illinois Public Service Co., 130 South Sixth Street, is reported planning construction of one-story ice-manufacturing plant on local site to cost more than $75,000 with equipment.

**Iowa, Fairfield**—The Iowa Electric Co., Merchants National Bank Building, Cedar Rapids, Iowa, has approved plans for immediate construction of transmission line from Fairfield to Farmington, including substation facilities.

**La., Jennings**—The Gulf States Utilities Co., Beaumont, Tex., is considering extensions and improvements in power substation at Jennings, including installation of addition equipment, estimated to cost $100,000.

**Mich., Allegan**—The City Council is having plans prepared for a municipal hydroelectric power plant on the Kalamazoo River, reported to cost in excess of $400,000 with transmission line. Ayres, Lewis, Morris & May, Cainwell Building, Ann Arbor, Mich., are engineers.

**Mich., Holland**—The Federal Stamping Co. will install power equipment in proposed new additions, reported to cost more than $300,000.

**Mich., Saginaw**—The Schust Co., Congress Street, will install power equipment in new five-story candy factory addition to cost about $200,000. C. Macomber, Board of Commerce Building, is architect.

**Mich., Vassar**—The Common Council is arranging a fund of $60,000 for extensions and improvements in the municipal electric power plant including installation of additional equipment.

**Mo., St. Louis**—The A. Leschen & Sons Rope Co., 5909 Kennerly Avenue, has filed plans for two-story boiler and engine house addition at wire rope plant, reported to cost more than $30,000.

**Miss., Fayette**—The City Council has completed plans for extensions and improvements in municipal electric power plant, including installation of additional equipment reported to cost about $25,000. Peter O'Brien, Edwards Hotel Building, Jackson, Miss., is engineer.

**N. H., Littleton**—The Grafton Light & Power Co., Grafton, Vt., operated by the New England Power Association, Worcester, Mass., has been granted permission to construct and operate two hydrolectric power plants on the Connecticut River at Fifteen Mile Falls, near Littleton, to develop an output of about 200,000 hp., reported to cost close to $15,000,000, with transmission lines, etc.

**N. J., Jersey City**—The American Can Co., 120 Broadway, New York, has filed plans for a two-story boiler plant, 90 x 100 ft., at factory on St. Pauls Avenue, Jersey City, to cost about $50,000.

**N. J., Jersey City**—Armour & Co., Union Stock Yards, Chicago, Ill., has filed plans for three-story meat packing plant, 120 x 130 ft., with cold storage and refrigerating division, on Seventh St., near Coles Street, reported to cost more than $750,000.

**N. Y., New York**—The New York Central Railroad Co., Grand Central Terminal, will install power equipment in connection with extensions and improvements in yards and shops at Mott Haven, entire project to cost more than $2,000,000.

**N. M., Las Vegas**—The Las Vegas Light & Power Co. has plans under way for extensions and improvements in steam-operated electric power plant to increase capacity by 1250 kva., reported to cost about $75,000.

**N. C., Durham**—The Golden Belt Mfg. Co. will install power equipment in new addition to hosiery mill to cost about $200,000.

**Ohio, Akron**—The Goodyear Rubber Co., South Main Street, plans installation of power equipment in proposed new additions reported to cost in excess of $100,000.

**Ohio, Cincinnati**—The Formica Insulation Co., Spring Grove Avenue, will install power equipment in a new three-story addition, reported to cost close to $100,000.

**Ohio, Cleveland**—The Peerless Motor Car Corporation, East Ninety-third Street, has plans under way for a one-story boiler plant and coal storage and distributing unit, reported to cost more than $50,000. Wilbur Watson & Associates, 4614 Prospect Street, are architects and engineers.

**Ohio, Cleveland**—The Spang Baking Co., 2701 Barber Avenue, will install power equipment in a new three-story baking plant addition to cost about $150,000. The G. S. Rider Co., Century Building, is architect.

**Ohio, Dayton**—The Leland Electric Co., Dayton, manufacturer of small motors, will build a one-story boiler house in connection with new plant addition to cost more than $150,000. The Ballinger Co., 105 South Twelfth Street, Philadelphia, Pa., is architect and engineer.

**Ohio, Toledo**—The Willys-Overland Co., Central Avenue, plans installation of power equipment in proposed new addition to automobile plant, entire project reported to cost more than $150,000.

**R. I., Providence**—The Providence Produce Warehouse Co., a subsidiary of the New York, New Haven & Hartford Railroad, has filed plans for two-story produce terminal warehouse, 90 x 965 ft., with cold storage, refrigerating and power departments, entire project to cost more than $500,000. Jenks & Ballou, Providence, are engineers.

**Tenn., Copperhill**—The Tennessee Copper & Chemical Corporation will install power equipment in proposed new plant addition, 200 x 420 ft., entire project to cost more than $400,000.

**Tenn., Nashville**—The Farris Hardwood Lumber Co. will install power equipment in connection with proposed rebuilding of mill, recently destroyed by fire with loss reported in excess of $130,000.

**Texas, Fort Worth**—The Trinity Portland Cement Co. will install power equipment in connection with new addition to mill to cost about $500,000, designed to double present capacity.

**Texas, McCamey**—The Phillips Petroleum Co., Bartlesville, Okla., will install power equipment in proposed natural gasoline plant at McCamey, entire project to cost more than $400,000.

**Va., West Point**—The Albemarle-Chesapeake Co., now being organized by officials of the Albemarle Paper Mfg. Co., Richmond, Va., is reported planning construction of new kraft paper mill to cost more than $1,000,000 including power house, power and mechanical equipment.

**Wis., Superior**—The National Lumber & Creosoting Co., Texarkana, Ark., plans installation of power equipment at new plant at Superior to cost about $250,000.